

# MAR ATHANASIOUS COLLEGE OF ENGINEERING

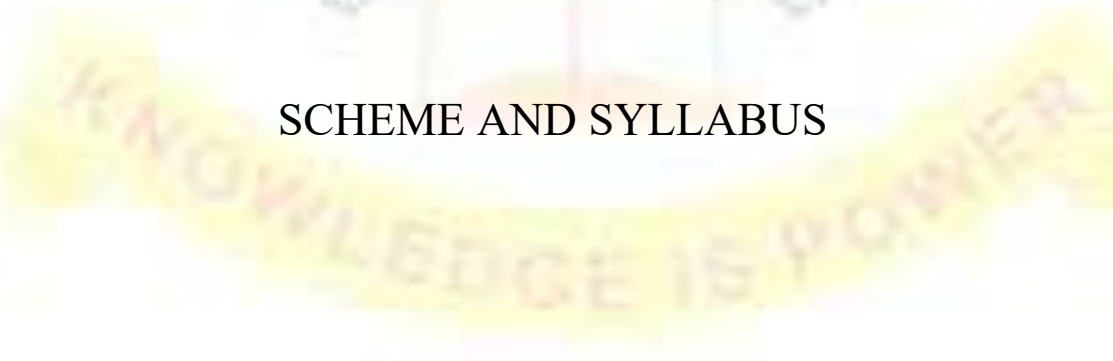
Government Aided, Autonomous Institution

Kothamangalam, Kerala, India

The logo of Mar Athanasius College of Engineering is a circular emblem. It features a large gear-like outer border. Inside the circle, there is a central cross. Below the cross, there are stylized green hills. The entire emblem is set against a light background.

## **B.TECH ELECTRONICS AND COMMUNICATION ENGINEERING**

SCHEME AND SYLLABUS

A yellow banner with the motto 'KNOWLEDGE IS POWER' in red capital letters, positioned at the bottom of the page.

| MAR ATHANASIOUS COLLEGE OF ENGINEERING KOTHAMANGALAM<br>DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING<br>UG CURRICULUM 2024 |            |                                                |         |       |        |
|---------------------------------------------------------------------------------------------------------------------------------------|------------|------------------------------------------------|---------|-------|--------|
| SEMESTER 1                                                                                                                            |            |                                                |         |       |        |
| SLOT                                                                                                                                  | COURSE NO. | COURSES                                        | L-T-P-S | HOURS | CREDIT |
| A                                                                                                                                     | B24MA1T01  | LINEAR ALGEBRA AND MULTI VARIABLE CALCULUS     | 3-1-0-5 | 4     | 4      |
| B                                                                                                                                     | B24ES1T01A | PROBLEM SOLVING AND PROGRAMMING TECHNIQUES(A)  | 2-1-0-4 | 3     | 3      |
| C                                                                                                                                     | B24PH1T01A | ENGINEERING PHYSICS(A)                         | 2-1-0-4 | 3     | 3      |
| D                                                                                                                                     | B24CY1T01A | ENGINEERING CHEMISTRY(A)                       | 2-1-0-4 | 3     | 3      |
| E                                                                                                                                     | B24ES1T02  | BASICS OF ELECTRICAL & ELECTRONICS ENGINEERING | 2-2-0-5 | 4     | 4      |
| F                                                                                                                                     | B24ES1L02  | BASIC ELECTRICAL AND ELECTRONICS WORKSHOP      | 0-0-2-1 | 2     | 1      |
| G                                                                                                                                     | B24ES1L01A | PROGRAMMING LAB(A)                             | 0-0-3-2 | 3     | 2      |
| H                                                                                                                                     | B24PC1L01A | PHYSICS(A) AND CHEMISTRY(A) LAB                | 0-0-2-2 | 2     | 1      |
| I                                                                                                                                     | B24MC1T01  | LIFE SKILLS                                    | 1-0-1-2 | 2     | P/F    |
| J                                                                                                                                     | B24MC1T02  | DESIGN THINKING                                | 1-1-0-2 | 2     | P/F    |
| K                                                                                                                                     | B24MC1L01  | YOGA AND SPORTS                                | 0-1-1-1 | 2     | P/F    |
|                                                                                                                                       |            | TOTAL                                          |         | 30    | 21     |
| SEMESTER 2                                                                                                                            |            |                                                |         |       |        |
| SLOT                                                                                                                                  | COURSE NO. | COURSES                                        | L-T-P-S | HOURS | CREDIT |
| A                                                                                                                                     | B24MA1T02  | ORDINARY DIFFERENTIAL EQUATIONS AND TRANSFORMS | 3-1-0-5 | 4     | 4      |
| B                                                                                                                                     | B24ES1T03A | COMPUTER AIDED ENGINEERING GRAPHICS (A)        | 2-0-2-4 | 4     | 3      |
| C                                                                                                                                     | B24EC1T02  | ELECTRICAL CIRCUIT THEORY                      | 3-1-0-5 | 4     | 4      |
| D                                                                                                                                     | B24EC1T03  | LOGIC CIRCUIT DESIGN                           | 2-1-0-4 | 3     | 3      |
| E                                                                                                                                     | B24EC1T04  | ANALOG CIRCUITS 1                              | 3-1-0-5 | 4     | 4      |
| G                                                                                                                                     | B24EC1L01  | BASIC ELECTRONICS LAB                          | 0-0-3-2 | 3     | 2      |
| H                                                                                                                                     | B24EC1L02  | SCIENTIFIC COMPUTING LAB                       | 0-0-3-2 | 3     | 2      |
| I                                                                                                                                     | B24MC1T03  | PROFESSIONAL COMMUNICATION AND ETHICS          | 2-0-1-4 | 3     | P/F    |
| J                                                                                                                                     | B24MC1L02  | IDEA LAB                                       | 0-0-2-2 | 2     | P/F    |
|                                                                                                                                       |            | TOTAL                                          |         | 30    | 22     |

| SEMESTER 3 |            |                                                      |         |       |        |
|------------|------------|------------------------------------------------------|---------|-------|--------|
| SLOT       | COURSE NO. | COURSES                                              | L-T-P-S | HOURS | CREDIT |
| A          | B24MA2T03A | COMPLEX VARIABLES AND APPLICATIONS OF PDE            | 3-1-0-5 | 4     | 4      |
| B          | B24EC2T01  | ANALOG CIRCUITS 2                                    | 3-1-0-5 | 4     | 4      |
| C          | B24EC2T02  | COMPUTER ARCHITECTURE AND MICROCONTROLLERS           | 3-1-0-5 | 4     | 4      |
| D          | B24EC2T03  | NETWORK THEORY                                       | 2-1-0-4 | 3     | 3      |
| E          | B24HU2T01  | BUSINESS ECONOMICS AND FINANCIAL MANAGEMENT          | 3-0-0-4 | 3     | 3      |
| G          | B24EC2L03  | LOGIC CIRCUIT DESIGN LAB                             | 0-0-3-2 | 3     | 2      |
| H          | B24EC2L04  | ELECTRONIC CIRCUITS LAB                              | 0-0-3-2 | 3     | 2      |
| I          | B24MC2T04  | UNIVERSAL HUMAN VALUE AND CONSTITUTIONAL RIGHTS      | 2-0-0-2 | 2     | P/F    |
| J          | B24MC2T05  | ENERGY CONSERVATION AND ENVIRONMENTAL SUSTAINABILITY | 2-0-0-2 | 2     | P/F    |
| M          | B24ECM3X   | MINOR                                                | 3-1-0-5 | 4     | 4      |
|            |            | TOTAL                                                |         | 32    | 22     |
| SEMESTER 4 |            |                                                      |         |       |        |
| SLOT       | COURSE NO. | COURSES                                              | L-T-P-S | HOURS | CREDIT |
| A          | B24MA2T04A | STOCHASTIC PROCESSES AND NUMERICAL METHODS           | 3-1-0-5 | 4     | 4      |
| B          | B24EC2T04  | SOLID STATE DEVICES                                  | 3-1-0-5 | 4     | 4      |
| C          | B24EC2T05  | SIGNALS AND SYSTEMS                                  | 3-1-0-5 | 4     | 4      |
| D          | B24EC2T06  | LINEAR INTEGRATED CIRCUITS                           | 3-1-0-4 | 4     | 3      |
| E          | B24HU2T02  | ENTREPRENEURSHIP AND MANAGEMENT SKILLS FOR ENGINEERS | 2-1-0-4 | 3     | 3      |
| F          | B24EC2T07  | FPGA BASED SYSTEM DESIGN                             | 2-1-0-4 | 3     | 3      |
| G          | B24EC2L05  | MICROCONTROLLER LAB                                  | 0-0-3-2 | 3     | 2      |
| H          | B24EC2L06  | HDL LAB                                              | 0-0-3-2 | 3     | 2      |
| M          | B24ECM4X   | MINOR                                                | 3-1-0-5 | 4     | 4      |
| N          | B24ECH4X   | HONORS                                               | 3-1-0-5 | 4     | 4      |
|            |            | TOTAL                                                |         | 36    | 25     |

| SEMESTER 5 |            |                                  |         |       |        |
|------------|------------|----------------------------------|---------|-------|--------|
| SLOT       | COURSE NO. | COURSES                          | L-T-P-S | HOURS | CREDIT |
| A          | B24EC3T01  | DIGITAL SIGNAL PROCESSING        | 3-1-0-5 | 4     | 4      |
| B          | B24EC3T02  | CONTROL SYSTEMS                  | 3-1-0-5 | 4     | 4      |
| C          | B24EC3T03  | ANALOG AND DIGITAL COMMUNICATION | 3-1-0-5 | 4     | 4      |
| D          | B24EC3T04  | VLSI DESIGN                      | 3-1-0-5 | 4     | 4      |
| E          | B24EC3T05  | EMBEDDED SYSTEMS                 | 2-1-0-4 | 3     | 3      |
| F          | B24EC3P1X  | PROGRAMME ELECTIVE I             | 2-1-0-4 | 3     | 3      |
| G          | B24EC3L07  | LINEAR INTEGRATED CIRCUITS LAB   | 0-0-3-2 | 3     | 2      |
| H          | B24EC3L08  | CONTROL SYSTEMS LAB              | 0-0-3-2 | 3     | 2      |
| M          | B24ECM5X   | MINOR                            | 3-1-0-5 | 4     | 4      |
| N          | B24ECH5X   | HONORS                           | 3-1-0-5 | 4     | 4      |
|            |            |                                  | TOTAL   | 36    | 26     |
| SEMESTER 6 |            |                                  |         |       |        |
| SLOT       | COURSE NO. | COURSES                          | L-T-P-S | HOURS | CREDIT |
| A          | B24EC3T06  | ELECTROMAGNETIC THEORY           | 3-1-0-5 | 4     | 4      |
| B          | B24EC3T07  | MACHINE LEARNING                 | 3-1-0-5 | 4     | 4      |
| C          | B24EC3T08  | POWER ELECTRONICS                | 3-1-0-5 | 4     | 4      |
| D          | B24EC3T09  | WIRELESS COMMUNICATION           | 3-1-0-5 | 4     | 4      |
| E          | B24EC3P2X  | PROGRAMME ELECTIVE II            | 2-1-0-4 | 3     | 3      |
| F          | B24EC3G1X  | OPEN ELECTIVE I                  | 2-1-0-4 | 3     | 3      |
| G          | B24EC3L09  | DIGITAL SIGNAL PROCESSING LAB    | 0-0-3-2 | 3     | 2      |
| H          | B24EC3L10  | MINI PROJECT                     | 0-0-3-2 | 3     | 2      |
| M          | B24ECM6X   | MINOR                            | 3-1-0-5 | 4     | 4      |
| N          | B24ECH6X   | HONORS                           | 3-1-0-5 | 4     | 4      |
|            |            |                                  | TOTAL   | 36    | 26     |

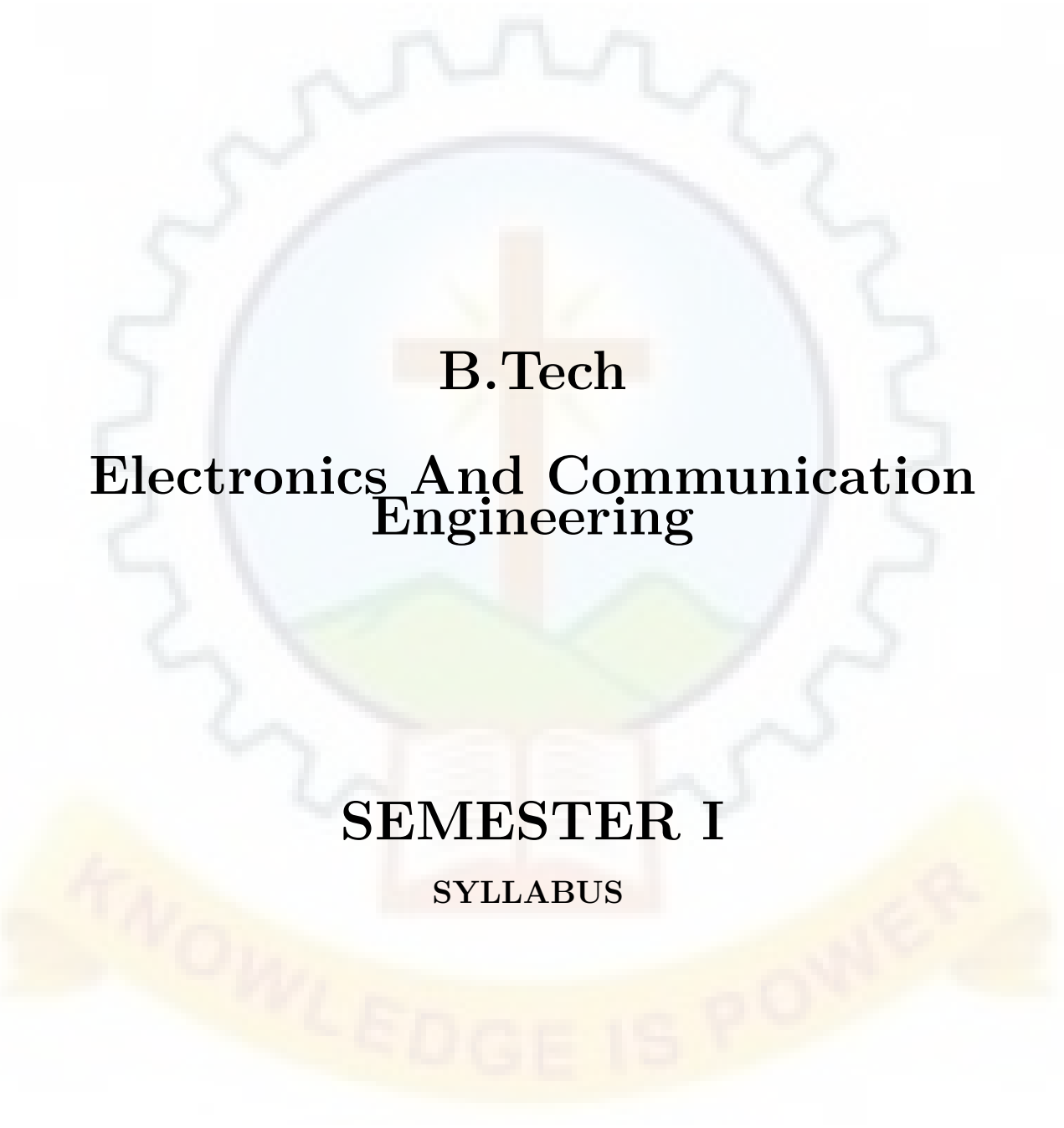
| SEMESTER 7 |            |                                           |          |       |        |
|------------|------------|-------------------------------------------|----------|-------|--------|
| SLOT       | COURSE NO. | COURSES                                   | L-T-P-S  | HOURS | CREDIT |
| A          | B24EC4T01  | INFORMATION THEORY AND CODING             | 2-1-0-4  | 3     | 3      |
| B          | B24EC4P3X  | PROGRAMME ELECTIVE III                    | 2-1-0-4  | 3     | 3      |
| C          | B24EC4P4X  | PROGRAMME ELECTIVE IV                     | 2-1-0-4  | 3     | 3      |
| D          | B24EC4G2X  | OPEN ELECTIVE II                          | 2-1-0-4  | 3     | 3      |
| E          | B24HU4T04  | DISASTER MANAGEMENT AND INDUSTRIAL SAFETY | 2-1-0-4  | 3     | 3      |
| G          | B24EC4L11  | COMMUNICATION LAB                         | 0-0-3-2  | 3     | 2      |
| H          | B24EC4L12  | PROJECT PHASE I                           | 0-0-6-2  | 6     | 3      |
| J          | B24EC4L13  | SEMINAR                                   | 0-0-4-1  | 4     | 2      |
| K          | B24EC4T02  | VIVA VOCE                                 | 0-0-0-0  | -     | 1      |
| M          | B24ECM7X   | MINOR                                     | 3-1-0-5  | 4     | 4      |
| N          | B24ECH7X   | HONORS                                    | 3-1-0-5  | 4     | 4      |
|            |            |                                           | TOTAL    | 36    | 23     |
| SEMESTER 8 |            |                                           |          |       |        |
| SLOT       | COURSE NO. | COURSES                                   | L-T-P-S  | HOURS | CREDIT |
| A, B, C    | B24MC400X  | INTERNSHIP & MOOC COURSES (3 NUMBERS)     | 0-0-0-0  | 0.00  | 9      |
| OR         |            |                                           |          |       |        |
| A          | B24EC4P5X  | PROGRAMME ELECTIVE V                      | 2-1-0-4  | 3     | 3      |
| B          | B24EC4P6X  | PROGRAMME ELECTIVE VI                     | 2-1-0-4  | 3     | 3      |
| C          | B24EC4G3X  | OPEN ELECTIVE III                         | 2-1-0-4  | 3     | 3      |
| AND        |            |                                           |          |       |        |
| H          | B24EC4L14  | PROJECT PHASE 2                           | 0-0-12-3 | 12    | 6      |
| M          | B24ECML8X  | MINOR PROJECT                             | 0-0-3-12 | 3     | 6      |
| N          | B24ECHL8X  | HONORS PROJECT                            | 0-0-6-9  | 6     | 6      |
|            |            |                                           | TOTAL    | 30    | 15     |

| MINOR - BASKET 1 (Electronic System Design)              |          |                                           |          |       |        |
|----------------------------------------------------------|----------|-------------------------------------------|----------|-------|--------|
| COURSE NO.                                               | SEMESTER | COURSES                                   | L-T-P-S  | HOURS | CREDIT |
| B24ECM31                                                 | III      | ELECTRONIC CIRCUITS                       | 3-1-0-5  | 4     | 4      |
| B24ECM41                                                 | IV       | MICROCONTROLLERS                          | 3-1-0-5  | 4     | 4      |
| B24ECM51                                                 | V        | EMBEDDED SYSTEM DESIGN                    | 3-1-0-5  | 4     | 4      |
| B24ECM61                                                 | VI       | VLSI CIRCUITS                             | 3-1-0-5  | 4     | 4      |
| B24ECM7X                                                 | VII      | MINIPROJECT                               | 3-1-0-5  | 4     | 4      |
| B24ECML8X                                                | VIII     | MINOR PROJECT                             | 0-0-3-12 | 3     | 6      |
| MINOR - BASKET 2 (Communication Systems and Networks)    |          |                                           |          |       |        |
| COURSE NO.                                               | SEMESTER | COURSES                                   | L-T-P-S  | HOURS | CREDIT |
| B24ECM32                                                 | III      | ANALOG COMMUNICATION                      | 3-1-0-5  | 4     | 4      |
| B24ECM42                                                 | IV       | DIGITAL COMMUNICATION                     | 3-1-0-5  | 4     | 4      |
| B24ECM52                                                 | V        | COMMUNICATION SYSTEMS                     | 3-1-0-5  | 4     | 4      |
| B24ECM62                                                 | VI       | DATA NETWORKS                             | 3-1-0-5  | 4     | 4      |
| B24ECM7X                                                 | VII      | MINIPROJECT                               | 3-1-0-5  | 4     | 4      |
| B24ECML8X                                                | VIII     | MINOR PROJECT                             | 0-0-3-12 | 3     | 6      |
| MINOR - BASKET 3 (Signal Processing and Computer Vision) |          |                                           |          |       |        |
| COURSE NO.                                               | SEMESTER | COURSES                                   | L-T-P-S  | HOURS | CREDIT |
| B24ECM33                                                 | III      | INTRODUCTION TO SIGNALS AND SYSTEMS       | 3-1-0-5  | 4     | 4      |
| B24ECM43                                                 | IV       | INTRODUCTION TO DIGITAL SIGNAL PROCESSING | 3-1-0-5  | 4     | 4      |
| B24ECM53                                                 | V        | INTRODUCTION TO DIGITAL IMAGE PROCESSING  | 3-1-0-5  | 4     | 4      |
| B24ECM63                                                 | VI       | INTRODUCTION TO COMPUTER VISION           | 3-1-0-5  | 4     | 4      |
| B24ECM7X                                                 | VII      | MINIPROJECT                               | 3-1-0-5  | 4     | 4      |
| B24ECML8X                                                | VIII     | MINOR PROJECT                             | 0-0-3-12 | 3     | 6      |

| HONOURS - BASKET 1 (Nanoelectronics and VLSI)       |          |                                            |         |       |        |
|-----------------------------------------------------|----------|--------------------------------------------|---------|-------|--------|
| COURSE NO.                                          | SEMESTER | COURSES                                    | L-T-P-S | HOURS | CREDIT |
| B24ECH41                                            | IV       | NANO ELECTRONICS                           | 3-1-0-5 | 4     | 4      |
| B24ECH51                                            | V        | SYSTEM VERILOG FOR DESIGN AND VERIFICATION | 3-1-0-5 | 4     | 4      |
| B24ECH61                                            | VI       | ELECTRONIC DESIGN AND AUTOMATION TOOLS     | 3-1-0-5 | 4     | 4      |
| B24ECH71                                            | VII      | RF MEMS                                    | 3-1-0-5 | 4     | 4      |
| B24ECHL8X                                           | VIII     | HONORS PROJECT                             | 0-0-6-9 | 6     | 6      |
| HONOURS - BASKET 2 (Advanced Communication Systems) |          |                                            |         |       |        |
| COURSE NO.                                          | SEMESTER | COURSES                                    | L-T-P-S | HOURS | CREDIT |
| B24ECH42                                            | IV       | STOCHASTIC PROCESSES FOR COMMUNICATION     | 3-1-0-5 | 4     | 4      |
| B24ECH52                                            | V        | DETECTION AND ESTIMATION THEORY            | 3-1-0-5 | 4     | 4      |
| B24ECH62                                            | VI       | MIMO AND MULTIUSER COMMUNICATION SYSTEMS   | 3-1-0-5 | 4     | 4      |
| B24ECH72                                            | VII      | DESIGN AND ANALYSIS OF ANTENNAS            | 3-1-0-5 | 4     | 4      |
| B24ECHL8X                                           | VIII     | HONORS PROJECT                             | 0-0-6-9 | 6     | 6      |
| HONOURS - BASKET 3 (Statistical Signal Processing)  |          |                                            |         |       |        |
| COURSE NO.                                          | SEMESTER | COURSES                                    | L-T-P-S | HOURS | CREDIT |
| B24ECH43                                            | IV       | STOCHASTIC SIGNAL PROCESSING               | 3-1-0-5 | 4     | 4      |
| B24ECH53                                            | V        | COMPUTATIONAL TOOLS FOR SIGNAL PROCESSING  | 3-1-0-5 | 4     | 4      |
| B24ECH63                                            | VI       | DETECTION AND ESTIMATION THEORY            | 3-1-0-5 | 4     | 4      |
| B24ECH73                                            | VII      | MULTIRATE SIGNAL PROCESSING AND WAVELETS   | 3-1-0-5 | 4     | 4      |
| B24ECHL8X                                           | VIII     | HONORS PROJECT                             | 0-0-6-9 | 6     | 6      |

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India



**B.Tech**

**Electronics And Communication  
Engineering**

**SEMESTER I**

**SYLLABUS**



| B24MA1T01 | LINEAR<br>ALGEBRA AND<br>MULTIVARI-<br>ABLE<br>CALCULUS | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|---------------------------------------------------------|---|---|---|---|--------|-------------------------|
|           |                                                         | 3 | 1 | 0 | 5 | 4      | 2024                    |

**Preamble**

This course introduces students to some basic mathematical ideas and tools which are at the core of any engineering course. A brief course in Linear Algebra familiarises students with some basic techniques in matrix theory which are essential for analyzing linear systems. The calculus of functions of one or more variables taught in this course are useful in modelling and analyzing physical phenomena involving continuous change of variables or parameters and have applications across all branches of engineering.

**Prerequisites:** Nil

**Course Outcomes**

After the completion of the course the student will be able to:

|             |                                                                                                                                        |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Solve systems of linear equations using matrix methods and determine eigenvalues, eigenvectors and canonical forms of quadratic forms. |
| <b>CO 2</b> | Calculate partial and total derivatives of multivariable functions and determine their extrema using differential calculus techniques. |
| <b>CO 3</b> | Apply double and triple integrals to determine areas, volumes, mass and centre of gravity of geometrical regions.                      |
| <b>CO 4</b> | Calculate derivatives and line integrals of vector functions and apply them to solve problems in vector calculus.                      |
| <b>CO 5</b> | Apply Green's, Stokes' and Divergence theorems to calculate line, surface and flux integrals and model engineering field problems.     |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 2    | 1    |      |      | 1    |      |      |      |      |       |       |
| <b>CO 2</b> | 2    | 1    |      |      |      | 1    |      |      |      |       |       |
| <b>CO 3</b> | 2    | 1    |      |      |      |      |      |      |      |       |       |
| <b>CO 4</b> | 2    | 1    |      |      |      |      |      |      |      |       |       |
| <b>CO 5</b> | 2    | 1    |      | 1    | 1    | 1    | 1    |      |      |       | 1     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 40                    | 40                 | 40                                    |
| Apply            | 40                    | 40                 | 40                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Quiz/Course Project         | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions carrying 3 marks each. Part B contains 2 questions from each module out of which 1 to be answered. Each question carries 14 marks and can have maximum 2 sub divisions.

## SYLLABUS

### MODULE 1 (Linear Algebra)

(Text 2: Relevant topics from 7.3, 7.4, 7.5, 8.1,8.3,8.4)

Systems of linear equations, Solution by Gauss elimination, row echelon form and rank of a matrix, fundamental theorem for linear systems (homogeneous and non-homogeneous,

without proof), Eigen values and eigenvectors. Diagonalization of matrices, orthogonal transformation, quadratic forms and their canonical forms.

## **MODULE 2 (Multivariable Calculus-Differentiation)**

**(Text 1: Relevant topics from sections 13.3, 13.4, 13.5, 13.8)**

Partial derivatives, partial derivatives of functions of more than two variables, higher order partial derivatives, differentials and local linearity, The chain rule, Maxima and Minima of functions of two variables, extreme value theorem (without proof), relative extrema.

## **MODULE 3 ((Multivariable Calculus-Integration))**

**(Text 1: Relevant topics from sections 14.1, 14.2, 14.3, 14.5, 14.6, 14.8)**

Double integrals (Cartesian), reversing the order of integration, Change of coordinates (Cartesian to polar), finding areas using double integrals, mass and centre of gravity of inhomogeneous laminas using double integral. Triple integrals, volume calculated as triple integral, triple integral in cylindrical and spherical coordinates (computations involving spheres, cylinders).

## **MODULE 4 (Calculus of vector functions)**

**(Text 1: Relevant topics from sections 12.1, 12.2, 12.6, 13.6, 15.1, 15.2, 15.3)**

Vector valued function of single variable, derivative of vector function and geometrical interpretation, motion along a curve-velocity, speed and acceleration. Concept of scalar and vector fields, Gradient and its properties, directional derivative, divergence and curl, Line integrals of vector fields, work as line integral, Conservative vector fields, independence of path and potential function(results without proof).

## **MODULE 5 (Vector integral theorems)**

**(Text 1: Relevant topics from sections 15.4, 15.5, 15.6, 15.7, 15.8)**

Green's theorem (for simply connected domains, without proof) and applications to evaluating line integrals and finding areas. Surface integrals over surfaces of the form  $z = g(x, y)$ ,  $y = g(x, z)$  or  $x = g(y, z)$ , Flux integrals over surfaces of the form  $z = g(x, y)$ ,  $y = g(x, z)$  or  $x = g(y, z)$ , divergence theorem (without proof) and its applications to finding flux integrals, Stokes' theorem (without proof) and its applications to finding line integrals of vector fields and work done.

### **Text Books**

1. H. Anton, I. Biven, S. Davis, "Calculus", Wiley, 10<sup>th</sup> edition, 2015.

2. Erwin Kreyszig, Advanced Engineering Mathematics, 10<sup>th</sup> edition, John Wiley & Sons, 2015.

### Reference Books

4. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9<sup>th</sup> Edition, Pearson, Reprint, 2002.
5. J. Stewart, Essential Calculus, Cengage, 2<sup>nd</sup> edition, 2017.
6. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 43<sup>rd</sup> Edition, 2015.
7. Peter O Neil, Advanced Engineering Mathematics, 7<sup>th</sup> Edition, Thomson, 2007.
8. Veerarajan T. Engineering Mathematics for first year, Tata McGraw - Hill, 2008.

### COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                       | No of Lecture/Tutorial Hours |
|-----|-----------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | Total                                                                                                                       | 45 hours                     |
| 1   | <b>Linear Algebra</b>                                                                                                       | 9                            |
| 1.1 | Systems of linear equations, Solution by Gauss elimination                                                                  | 1                            |
| 1.2 | Row echelon form, finding rank from row echelon form, fundamental theorem for linear systems                                | 2                            |
| 1.3 | Eigen values and eigen vectors                                                                                              | 2                            |
| 1.4 | Diagonalization of matrices                                                                                                 | 2                            |
| 1.5 | Orthogonal transformation, quadratic forms and their canonical forms.                                                       | 2                            |
| 2   | <b>Multivariable Calculus - Differentiation</b>                                                                             | 9                            |
| 2.1 | Partial derivatives                                                                                                         | 2                            |
| 2.2 | Differentials, Local Linear approximations                                                                                  | 2                            |
| 2.3 | Chain rule, total derivative                                                                                                | 2                            |
| 2.4 | Maxima and minima                                                                                                           | 3                            |
| 3   | <b>Multivariable Calculus - Integration</b>                                                                                 | 9                            |
| 3.1 | Double integrals (Cartesian)-evaluation                                                                                     | 2                            |
| 3.2 | Change of order of integration in double integrals, change of coordinates (Cartesian to polar)                              | 2                            |
| 3.3 | Finding areas, mass and centre of gravity of plane laminae                                                                  | 2                            |
| 3.4 | Triple integrals, volume calculated as triple integral, triple integral in cylindrical and spherical coordinates.           | 3                            |
| 4   | <b>Calculus of Vector Functions</b>                                                                                         | 9                            |
| 4.1 | Vector valued function of a scalar variable - derivative of vector valued function of scalar variable t-geometrical meaning | 2                            |

|     |                                                                                                        |   |
|-----|--------------------------------------------------------------------------------------------------------|---|
| 4.2 | Motion along a curve-speed, velocity, acceleration                                                     | 1 |
| 4.3 | Gradient and its properties, directional derivative, divergence and curl                               | 3 |
| 4.4 | Line integrals with respect to arc length, line integrals of vector fields. Work done as line integral | 2 |
| 4.5 | Conservative vector field, independence of path, potential function                                    | 1 |
| 5   | <b>Vector Integral Theorems</b>                                                                        | 9 |
| 5.1 | Green's theorem and it's applications                                                                  | 2 |
| 5.2 | Surface integrals, flux integral and their evaluation                                                  | 3 |
| 5.3 | Divergence theorem and applications                                                                    | 2 |
| 5.4 | Stokes theorem and applications                                                                        | 2 |

### CO ASSESSMENT QUESTIONS

**Course Outcome 1 (CO 1):** Solve systems of linear equations, diagonalize matrices and characterise quadratic forms.

1. A is a real matrix of order  $3 \times 3$  and  $X = \begin{bmatrix} x \\ y \\ z \end{bmatrix}$ . What can you say about the solution of  $AX = 0$  if rank of A is 2 ? 3 ?
2. Given  $A = \begin{bmatrix} 3 & 0 & 2 \\ 0 & 2 & 0 \\ -2 & 0 & 0 \end{bmatrix}$ , find an orthogonal matrix  $P$  that diagonalizes  $A$ .
3. The matrix  $A = \begin{bmatrix} -2 & 2 & -3 \\ 2 & 1 & -6 \\ -1 & -2 & 0 \end{bmatrix}$  has an eigenvalue 5 with corresponding eigenvector  $X = \begin{bmatrix} 1 \\ 2 \\ -1 \end{bmatrix}$ . Find  $A^5 X$ .

**Course Outcome 2 (CO 2):** Compute the partial and total derivatives and maxima and minima of multivariable functions.

1. Find the slope of the surface  $z = x^2y + 5y^3$  in the  $x$ -direction at the point  $(1, -2)$ .
2. Given the function  $w = xy + z$ , use the chain rule to find the instantaneous rate of change of  $w$  at each point along the curve  $x = \cos t$ ,  $y = \sin t$ ,  $z = t$ .
3. Determine the dimension of rectangular box open at the top, having a volume 32 cubic ft and requiring the least amount of material for it's construction.



**Course Outcome 3 (CO 3):** Compute multiple integrals and apply them to find areas and volumes of geometrical shapes, mass and centre of gravity of plane laminas.

1. Evaluate  $\iint_D (x + 2y) dA$  where D is the region bounded by the parabolas  $y = 2x^2$  and  $y = 1 + x^2$ .
2. Explain how you would find the volume under the surface  $z = f(x, y)$  and over a specific region D in the  $xy$  plane using triple integral?
3. Find the mass and centre of gravity of a triangular lamina with vertices (0,0), (2,1), (0,3) if the density function is  $f(x, y) = x + y$ .

**Course Outcome 4 (CO 4):** Compute the derivatives and line integrals of vector functions and learn their applications

1. How would you calculate the speed, velocity and acceleration at any instant of a particle moving in space whose position vector at time  $t$  is  $\mathbf{r}(t)$  ?
2. Find the work done by the force field  $\mathbf{F} = (e^x - y^3) \mathbf{i} + (\cos y + x^3) \mathbf{j}$  on a particle that travels once around the unit circle centered at origin having radius 1.
3. When do you say that a vector field is conservative? What are the implications if a vector field is conservative?

**Course Outcome 5 (CO 5):** Evaluate surface and volume integrals and learn their inter-relations and applications

1. Write any one application each of line integral, double integral and surface integral.
2. Use the divergence theorem to find the outward flux of the vector field  $\mathbf{F}(x, y, z) = z\mathbf{k}$  across  $x^2 + y^2 + z^2 = a^2$ .
3. State Greens theorem. Use Green's theorem to express the area of a plane region bounded by a curve as a line integral.

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

FIRST SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2024

**Course Code: B24MA1T01**

**Course Name: LINEAR ALGEBRA AND MULTIVARIABLE CALCULUS**

**Common to all branches**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks.**

1. Determine the rank of the matrix  $\begin{bmatrix} 1 & 2 & -1 \\ -2 & -4 & 2 \\ 3 & 6 & -3 \end{bmatrix}$
2. Write down the eigen values of  $A = \begin{bmatrix} 2 & 0 \\ 0 & -1 \end{bmatrix}$
3. Find  $f_x(1,3)$  and  $f_y(1,3)$  for the function  $f(x,y) = 2x^3y^2 + 2y + 4x$ .
4. Show that the function  $u(x,t) = \sin(x-ct)$  is a solution of the equation  $\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$ .
5. Use double integral to find the area of the region enclosed between the parabola  $y = \frac{x^2}{2}$  and the line  $y = 2x$ .
6. Use polar coordinates to evaluate the area of the region bounded by  $x^2 + y^2 = 4$ , the line  $y = x$  and the y axis in the first quadrant.
7. Is the vector  $\mathbf{r}$  where  $\mathbf{r} = x\mathbf{i} + y\mathbf{j} + z\mathbf{k}$  conservative. Justify your answer.
8. Find a unit vector normal to the surface  $x^3 + y^3 + 3xyz = 3$  at the point  $(1,2,-1)$ .
9. What is the outward flux of  $\mathbf{F}(x,y,z) = x\mathbf{i} + y\mathbf{j} + z\mathbf{k}$  across any unit cube.
10. What is the relationship between Green's theorem and Stokes theorem?

**PART B**

**Answer any one question from each module. Each question carries 14 marks.**

11. (a) Solve the following system of equations

$$y + z - 2w = 0$$

$$2x - 3y - 3z + 6w = 2$$

$$4x + y + z - 2w = 4$$

7

- (b) Find the eigen values and eigen vectors of the matrix  $\begin{bmatrix} 2 & 2 & -3 \\ 2 & 1 & -6 \\ -1 & 2 & 0 \end{bmatrix}$

7

**OR**

12. (a) Diagonalize the matrix  $\begin{bmatrix} -1 & 2 & -2 \\ 2 & 4 & 1 \\ 2 & 4 & 1 \end{bmatrix}$

7

- (b) What kind of conic section the quadratic form  $3x^2 + 22xy + 3y^2 = 0$  represents? Transform it to principal axes.

7

13. (a) Find the local linear approximation to  $f(x, y) = \sqrt{x^2 + y^2}$  at the point (3,4). Use it to approximate  $f(3.04, 3.98)$ .

7

- (b) Let  $w = \sqrt{x^2 + y^2 + z^2}$ ,  $x = \cos\theta$ ,  $y = \sin\theta$ ,  $z = \tan\theta$ . Use chain rule to find  $\frac{dw}{d\theta}$  when  $\theta = \frac{\pi}{4}$

7

**OR**

14. (a) Let  $z = f(x, y)$  where  $x = r\cos\theta$ ,  $y = r\sin\theta$ , prove that

$$\left(\frac{\partial z}{\partial x}\right)^2 + \left(\frac{\partial z}{\partial y}\right)^2 = \left(\frac{\partial z}{\partial r}\right)^2 + \frac{1}{r^2} \left(\frac{\partial z}{\partial \theta}\right)^2$$

7

- (b) Locate all relative maxima, relative minima and saddle points of  $f(x, y) = xy + \frac{a^3}{x} + \frac{b^3}{y}$ , ( $a \neq 0, b \neq 0$ ).

7

15. (a) Evaluate  $\iint_D (2x^2y + 9y^3) dx dy$  where  $D$  is the region bounded by  $y = \frac{2}{3}x$  and  $y = 2\sqrt{x}$ .

- (b) Evaluate  $\int_0^4 \int_{\sqrt{y}}^2 e^{x^3} dx dy$  by changing the order of integration.

7

**OR**

16. (a) Find the volume of the solid bounded by the cylinder  $x^2 + y^2 = 4$  and the planes  $y + z = 4$  and  $z = 0$ .

7

- (b) Evaluate  $\iiint \sqrt{1 - x^2 - y^2 - z^2} dx dy dz$ , taken throughout the volume of the sphere  $x^2 + y^2 + z^2 = 1$

7

17. (a) Prove that the force field  $\mathbf{F} = e^y \mathbf{i} + xe^y \mathbf{j}$  is conservative in the entire xy-plane.

7



- (b) Find the work done in moving a particle along a straight line from (0,0,0) to (2,1,3) by the force  $\mathbf{F} = 3x^2\mathbf{i} + (2xz - y)\mathbf{j} + z\mathbf{k}$  7

OR

18. (a) Find the divergence of the vector field  $\mathbf{F} = x^3y^2z\mathbf{i} + xyz^3\mathbf{j} + xyz^2\mathbf{k}$  at (1,1,1). 7  
(b) Find the work done by the force field  $\mathbf{F}(x, y, z) = xy\mathbf{i} + yz\mathbf{j} + xz\mathbf{k}$  along C where C is the curve  $\mathbf{r}(t) = t\mathbf{i} + t^2\mathbf{j} + t^3\mathbf{k}$ . 7
19. (a) Use divergence theorem to find the outward flux of the vector field  $\mathbf{F} = 2x\mathbf{i} + 3y\mathbf{j} + z^3\mathbf{k}$  across the unit cube bounded by  $x = 0, y = 0, z = 0, x = 1, y = 1, z = 1$ . 7  
(b) Find the circulation of  $\mathbf{F} = (x - z)\mathbf{i} + (y - x)\mathbf{j} + (z - xy)\mathbf{k}$  using Stokes theorem around the triangle with vertices A(1,0,0), B(0,2,0) and C(0,0,1). 7

OR

20. (a) Use divergence theorem to find the volume of the cylindrical solid bounded by  $x^2 + 4x + y^2 = 7, z = -1, z = 4$  given the vector field  $\mathbf{F} = x\mathbf{i} + y\mathbf{j} + z\mathbf{k}$  across surface of the cylinder. 7  
(b) Use Stokes theorem to evaluate  $\int_C \mathbf{F} \cdot d\mathbf{r}$  where  $\mathbf{F} = x^2\mathbf{i} + 3x\mathbf{j} - y^3\mathbf{k}$  where C is the circle  $x^2 + y^2 = 1$  in the xy-plane with counterclockwise orientation looking down the positive z-axis. 7

| B24ES1T01A | PROBLEM SOLVING AND PROGRAMMING TECHNIQUES(A) | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|------------|-----------------------------------------------|---|---|---|---|--------|----------------------|
|            |                                               | 2 | 1 | 0 | 4 |        |                      |

### Preamble

This course shall prepare Engineering Graduates to write versatile C programs for solving computational problems that they come across in their professional life. The subject covers the basics of C programming, array handling, string manipulations, function creation, structure and pointer operations and file processing. On completing this course a learner will be able to write efficient C programs to solve real world computational problems.

### Prerequisites

Nil

### Course Outcomes

After the completion of the course the student will be able to:

|      |                                                                                                                                                                                                                             |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Analyze a computational problem and try to solve it using algorithms, flowcharts and also develop C programs from them using Arithmetic, Logical, Relational and Bitwise operators. (Cognitive Knowledge Level: Understand) |
| CO 2 | Develop C programs with branching and looping statements for processing arrays and matrices (Cognitive Knowledge Level: Apply)                                                                                              |
| CO 3 | Divide a given computational problem into a number of modules and develop functions to find the solution to the computational problem and also create programs for string processing (Cognitive Knowledge Level: Apply)     |
| CO 4 | Develop C programs which use structures and pointers for data processing and parameter passing (Cognitive Knowledge Level: Apply)                                                                                           |
| CO 5 | Develop C programs for file processing (Cognitive Knowledge Level: Apply)                                                                                                                                                   |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 3    | 3    | 3    | 0    | 1    | 1    | 1    | 1    | 1     | 1     |
| CO 2 | 3    | 3    | 3    | 3    | 0    | 1    | 1    | 1    | 0    | 1     | 1     |
| CO 3 | 3    | 3    | 3    | 3    | 0    | 1    | 1    | 1    | 0    | 1     | 1     |
| CO 4 | 3    | 3    | 3    | 3    | 0    | 1    | 1    | 1    | 0    | 1     | 1     |
| CO 5 | 3    | 3    | 3    | 3    | 0    | 1    | 1    | 1    | 0    | 1     | 1     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         |                       |                 |                                    |
| Understand       | 40                    | 40              | 40                                 |
| Apply            | 60                    | 60              | 60                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Quiz/Course Project         | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions carrying 3 marks

each. Part B contains 2 questions from each module out of which 1 to be answered. Each question carries 14 marks and can have maximum 2 sub divisions.

## **SYLLABUS**

### **MODULE 1 (6 hours)**

#### **Problem solving:**

Problem solving using Algorithms, Pseudocode and Flowcharts.

#### **C fundamentals:**

Character set, Constants, Identifiers, Keywords, Basic data types, Variables, Operators and its precedence, Bitwise operators, Expressions, Statements, Input and Output statements– Structure of a C program– simple programs.

### **MODULE 2 (9 hours)**

#### **Control statements:**

If, if-else, nested if, switch , while, do-while, for, break & continue, nested loops. Single dimensional arrays – defining an array, array initialization, accessing array elements, Enumerated data type, Two-dimensional arrays – defining a two-dimensional array – Programs for matrix processing - Programs for Sequential search, Bubble sort.

### **MODULE 3 (8 hours)**

#### **Strings:**

Declaring a string variable, reading and displaying strings, string related library functions – Programs for string matching.

#### **Functions:**

Function definition, function call, function prototype, parameter passing – Recursion – Passing array to function. Macros: Defining and calling macros.

### **MODULE 4 (8 hours)**

#### **Structures:**

Defining a structure variable, accessing members, array of structures, passing structure to function. Union, Pointers: declaration, operations on pointers, passing pointer to a function,

accessing array elements using pointers, processing strings using pointers, pointer to pointer, array of pointers, pointer to function, pointer to structure, Dynamic memory allocation.

## **MODULE 5 (4 hours)**

### **Files:**

Different types of files in C – Opening Closing a file – Writing to and Reading from a file – Processing files – Library functions related to file – fseek(), ftell(), fread(), fwrite(). Storage Class associated with variables: automatic, static, external and register.

### **Text Books**

1. Programming with C - Byron S. Gottfried, Tata McGraw Hill
2. Computer Programming in C - Kerninghan & Ritchie, PHI

### **Reference Books**

1. Programming in C - Stephen C. Kochan, CBS publishers.
2. Programming in C – E. Balaguruswamy , Mc Graw Hill.
3. Let us C – Yashwant Kanetkar, BPB.
4. A Book on C – Al Kelley and Ira Pohl, Addison-Wesley.
5. Mastering Turbo C - Stan Kelly Bootle, BPB Publications.
6. Pointers in C - Yashwant Kanetkar, BPB.
7. The Spirit of C- by Munish cooper, Jaico Books.

## **COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                        | No of Lecture/Tutorial Hours |
|-----|--------------------------------------------------------------|------------------------------|
|     | Total Hours                                                  | 35 Hours                     |
|     | <b>Module 1: C fundamentals</b>                              | 6                            |
| 1.1 | Problem solving using Algorithms, Pseudocode and Flowcharts. | 1                            |
| 1.2 | C fundamentals: Character set, Constants, Identifiers.       | 1                            |

|     |                                                                                                |   |
|-----|------------------------------------------------------------------------------------------------|---|
| 1.3 | Keywords, Basic data types, Variables.                                                         | 1 |
| 1.4 | Operators and its precedence, bitwise operators.                                               | 1 |
| 1.5 | Expressions, Statements, Input and Output statements.                                          | 1 |
| 1.6 | Structure of a C program– simple programs.                                                     | 1 |
|     | <b>Module 2: Control statements:</b>                                                           | 9 |
| 2.1 | Control statements: if, if-else, nested if .                                                   | 1 |
| 2.2 | Switch, while loop, do-while loop.                                                             | 1 |
| 2.3 | For loop, break & continue statements, nested loops.                                           | 1 |
| 2.4 | Single dimensional arrays – defining an array, array initialization, accessing array elements. | 1 |
| 2.5 | Two-dimensional arrays – defining a two-dimensional array.                                     | 1 |
| 2.6 | Programs for matrix processing.                                                                | 1 |
| 2.7 | Programs for sequential search.                                                                | 1 |
| 2.8 | Bubble sort.                                                                                   | 1 |
| 2.9 | Enumerated data type.                                                                          | 1 |
|     | <b>Module 3: Strings and Functions</b>                                                         | 8 |
| 3.1 | Strings: declaring a string variable, reading and displaying strings.                          | 1 |
| 3.2 | String related library functions.                                                              | 1 |
| 3.3 | Programs for string matching.                                                                  | 1 |
| 3.4 | Functions: Function definition, Function call.                                                 | 1 |
| 3.5 | Function prototype, Parameter passing.                                                         | 1 |
| 3.6 | Recursion.                                                                                     | 1 |
| 3.7 | Passing array to function.                                                                     | 1 |
| 3.8 | Macros: Defining and calling macros.                                                           | 1 |
|     | <b>Module 4: Structures</b>                                                                    | 8 |
| 4.1 | Structures: defining a structure variable, accessing members.                                  | 1 |
| 4.2 | Array of structures, passing structure to function.                                            | 1 |
| 4.3 | Union.                                                                                         | 1 |
| 4.4 | Pointers: declaration, operations on pointers, pointer to a function.                          | 1 |
| 4.5 | Accessing array elements using pointers, Processing strings using pointers.                    | 1 |
| 4.6 | Pointer to pointer, Array of pointers.                                                         | 1 |
| 4.7 | Pointer to function, Pointer to structure.                                                     | 1 |
| 4.8 | Dynamic memory allocation.                                                                     | 1 |
|     | <b>Module 5: Files</b>                                                                         | 4 |
| 5.1 | Different types of files in C, Opening & Closing a file.                                       | 1 |
| 5.2 | Writing to and Reading from a file, Processing file.                                           | 1 |
| 5.3 | Library functions related to file – fseek(), ftell(), fread(), fwrite().                       | 1 |
| 5.4 | Storage Class associated with variables: automatic, static, external and register.             | 1 |



## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1):**

1. Write an algorithm and pseudocode to check if a given number is an Armstrong number or not
2. Draw a flow chart to check if a given number is an Armstrong number or not.

### **Course Outcome 2 (CO 2):**

1. Write a C program to find the smallest number, largest number and the number of occurrences from a set of numbers.
2. Write a C program to add two matrices.

### **Course Outcome 3 (CO 3):**

1. Write a C program to find whether a string is present in another string.
2. Write functions to accept an N X N matrix and find the row sum and column sum of the matrix.

### **Course Outcome 4 (CO 4):**

1. Write a C program to find the difference between two time intervals using structure.
2. Write a C program to check if a given string is palindrome using pointers.

### **Course Outcome 5 (CO 5):**

1. Write a C program to count the number of lines in a file.
2. The name of some students and their marks in 5 subjects are given in a file. Write a C program to read the student details and calculate the total marks and write the name and total marks to another file.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 2**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**First SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2024**

**Course Code: B24ES1T01A**

**Course Name: PROBLEM SOLVING AND PROGRAMMING TECHNIQUES (A)**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks.**

1. Draw a flow chart to find the largest of three numbers.
2. Write a C program to convert Fahrenheit temperature to Celsius.
3. Differentiate between while loop and do-while loop.
4. Write a C program to find all the factors of a number.
5. Explain any 3 string handling functions using examples.
6. Differentiate between macros and functions.
7. What are the advantages of using structure in C language..
8. Explain pointer to a pointer with an example.
9. Write any three file handling functions in C.
10. What is a static variable? When should it be used?

**PART B**

**Answer any one question from each module. Each question carries 14 marks.**

11. Explain linear search with an example. Draw a flowchart and write pseudo code to perform linear search on an array of numbers. 14

**OR**

12. (a) Write a C program to find the area of a triangle given the length of three sides of the triangle. 7  
(b) Write a C program to find the Area and Circumference of a Circle given the radius of the circle. 7
13. (a) Write a C program to find the transpose of a matrix. 7  
(b) Write a C program to sort an array of numbers using bubble sort 7

**OR**

14. (a) Write a C program to find the sum of first and last digit of a number. 7  
(b) Write a C program to print all the prime numbers between 100 to 200. 7
15. (a) Explain any 4 string handling functions in C programming. 7  
(b) Write a C program to reverse a string without using string handling functions. 7

**OR**

16. (a) What is the purpose of function declaration and function definition and function call? With examples illustrate their syntax 7  
(b) What is recursion? Write a C program to display Fibonacci series using recursive function. 7
17. (a) Write a C program to: 7  
i. Create a structure with fields: Name, Address, Date of Birth.  
ii. Read the above details for five students from user and display the details.  
(b) Differentiate between array of pointers and pointer to an array.. 7

**OR**

18. (a) What are the different dynamic memory allocation functions available in C language. 7  
(b) Write a C program to reverse a string using pointers. 7
19. (a) What are different storage classes in C? Give examples for each. . 7  
(b) Explain any 5 file handling functions in C? 7

**OR**

20. (a) Write a C program to count number of lines in a text file. 7  
(b) Write a C program to read a text file and replace all vowels in the text file with character 'x' and write it to another file.. 7

| B24PH1T01A | ENGINEERING<br>PHYSICS (A) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|------------|----------------------------|---|---|---|---|--------|-------------------------|
|            |                            | 2 | 1 | 0 | 4 |        |                         |

### Preamble

The aim of this course is to equip students with a solid foundation in physics principles and knowledge of their engineering applications. This will enhance the students' ability to analyze and solve complex engineering problems. Ultimately, the goal is to produce graduates who are well prepared to tackle real world engineering challenges with a deep understanding of the underlying physical principles.

### Prerequisites

Nil

### Course Outcomes

After the completion of the course the student will be able to:

|      |                                                                                                                                                                                           |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Explain the principles of lasers and optical fibers, including Einstein's relations and numerical aperture, and apply them to understand intensity-modulated sensors.                     |
| CO 2 | Formulate and solve the time-independent Schrödinger equation for a particle in a one-dimensional box, interpreting wave functions and energy eigenvalues.                                |
| CO 3 | Analyze electrical conduction in solids using Fermi-Dirac statistics and evaluate the charge carrier concentrations in intrinsic semiconductors.                                          |
| CO 4 | Evaluate carrier concentrations in extrinsic semiconductors and interpret the variation of the Fermi level with temperature and doping concentration.                                     |
| CO 5 | Illustrate the formation, energy band diagrams, and working of PN junctions and photonic devices (LEDs, photodiodes, solar cells) for sustainable energy and optoelectronic applications. |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 2    | 1    |      | 1    | 1    | 1    |      |      | 1    |       | 1     |
| CO 2 | 2    | 1    |      |      |      |      |      |      | 1    |       | 1     |
| CO 3 | 2    | 1    |      |      |      |      |      |      | 1    |       |       |
| CO 4 | 2    | 1    |      |      |      |      |      |      | 1    |       |       |
| CO 5 | 2    | 1    |      |      | 1    |      |      |      | 1    |       | 1     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 30                    | 30                 | 30                                    |
| Understand       | 50                    | 50                 | 50                                    |
| Apply            | 20                    | 20                 | 20                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 20 Marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Quiz/Course Project         | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions carrying 3 marks each. Part B contains 2 questions from each module out of which 1 to be answered. Each question carries 14 marks and can have maximum 2 sub divisions.

## SYLLABUS

### MODULE 1 (7 hours)

#### Laser & Fibre Optics:

Optical processes - Absorption, Spontaneous emission and stimulated emission, - Einstein's relations. Principle of laser - conditions for sustained lasing - components of laser - Population inversion - energy source - Pumping, Metastable states - active medium, optical

resonator. Construction and working of Ruby laser. Optic fiber-Principle of propagation of light, Numerical aperture – Derivation. Applications of fibers - Intensity modulated sensors.

## **MODULE 2 (8 hours)**

### **Quantum Mechanics:**

Introduction - Concept of uncertainty and conjugate observables (qualitative), Uncertainty principle (statement only), Wave function, its properties and physical interpretation, Formulation of time dependent and time independent Schrodinger equations, Particle in a one dimensional box - Derivation of energy eigenvalues and normalized wave function.

## **MODULE 3 (8 hours)**

### **Semiconductor Physics I :**

Electrical Conduction in solids - Density of states function (no derivation), the Fermi-Dirac Probability function, Fermi energy and its physical significance, Charge carriers in semiconductors - Equilibrium distribution of electrons and holes, the  $n_0$  and  $p_0$  equations, Intrinsic carrier concentration  $n_i$ , Intrinsic Fermi level position and its dependence on temperature.

## **MODULE 4 (7 hours)**

### **Semiconductor Physics II :**

Extrinsic semiconductors - P type semiconductor, N type semiconductor, Carrier concentration in N type semiconductor, Variation of fermi level with temperature, Variation of fermi level with donor concentration, Carrier concentration in P type semiconductor, Variation of fermi level with temperature, Variation of fermi level with acceptor concentration.

## **MODULE 5 (6 hours)**

### **Semiconductor Devices:**

Formation of PN junction, Energy band diagram of PN junction - Qualitative description of charge flow across a PN junction - Forward and reverse biased PN Junctions, Photonic devices (Qualitative treatment only) - Light Emitting Diode, Photo detectors (Junction and PIN photodiodes), Solar cells.

### **Text Books**

1. Aruldas G., "Engineering Physics", PHI Pvt. Ltd., 2015.
2. M.N. Avadhanulu, P.G. Kshirsagar, TVS Arun Murthy, "A Textbook of Engineering Physics", S.Chand & Co., Revised Edition, 2019.
3. Donald A. Neamen, "Semiconductor Physics and Devices - Basic Principles", McGraw Hill, 4<sup>th</sup> Edition, 2012.



## Reference Books

4. Arthur Beiser, "Concepts of Modern Physics ", Tata McGraw Hill Publications, 6<sup>th</sup> Edition 2003.
5. D.K. Bhattacharya, Poonam Tandon, "Engineering Physics", Oxford University Press, 2015.
6. Md.N.Khan & S.Panigrahi "Principles of Engineering Physics 1&2", Cambridge University Press, 2016.
7. Aruldas G., "Engineering Physics", PHI Pvt. Ltd., 2015.
8. S.M. Sze, "Physics of Semiconductor Devices", John Wiley & Sons, 1969.

## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                                                            | No of Lecture/Tutorial Hours |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | Total Hours                                                                                                                                                                                      | 36 Hours                     |
|     | <b>Module 1: Laser and Fibre Optics</b>                                                                                                                                                          | 7                            |
| 1.1 | Optical processes - Absorption, Spontaneous emission and stimulated emission, - Einstein's relations                                                                                             | 2                            |
| 1.2 | Principle of laser - conditions for sustained lasing - components of laser - Population inversion - energy source - Pumping, Metastable states - active medium, optical resonator.               | 2                            |
| 1.3 | Construction and working of Ruby laser.                                                                                                                                                          | 1                            |
| 1.4 | Optic fiber-Principle of propagation of light, Numerical aperture – Derivation                                                                                                                   | 1                            |
| 1.5 | Applications of fibers - Intensity modulated sensors .                                                                                                                                           | 1                            |
|     | <b>Module 2: Quantum Mechanics</b>                                                                                                                                                               | 7                            |
| 2.1 | Introduction - Concept of uncertainty and conjugate observables (qualitative), Uncertainty principle (statement only),                                                                           | 1                            |
| 2.2 | Wave function, its properties and physical interpretation.                                                                                                                                       | 1                            |
| 2.3 | Formulation of time dependent and time independent Schrodinger equations, Particle in a one dimensional box - Derivation of energy eigenvalues and normalized wave function, Numerical Problems. | 5                            |
|     | <b>Module 3: Semiconductor Physics I</b>                                                                                                                                                         | 8                            |
| 3.1 | Electrical Conduction in solids - Density of states function (no derivation), the Fermi-Dirac Probability function, Fermi energy and its physical significance                                   | 2                            |

|     |                                                                                                                                                                                                                 |   |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 3.2 | Charge carriers in semiconductors - Equilibrium distribution of electrons and holes, the $n_0$ and $p_0$ equations.                                                                                             | 3 |
| 3.3 | Intrinsic carrier concentration $n_i$ , Intrinsic Fermi level position and its dependence on temperature.                                                                                                       | 3 |
|     | <b>Module 4: Semiconductor Physics II</b>                                                                                                                                                                       | 8 |
| 4.1 | Extrinsic semiconductors - P type semiconductor, N type semiconductor.                                                                                                                                          | 2 |
| 4.2 | Carrier concentration in N type semiconductor, Variation of fermi level with temperature, Variation of fermi level with donor concentration                                                                     | 3 |
| 4.3 | Carrier concentration in P type semiconductor, Variation of fermi level with temperature, Variation of fermi level with acceptor concentration                                                                  | 3 |
|     | <b>Module 5: Semiconductor Devices</b>                                                                                                                                                                          | 6 |
| 5.1 | Formation of PN junction, Energy band diagram of PN junction - Qualitative description of charge flow across a PN junction - Forward and reverse biased PN Junctions, the ideal diode equation (no derivation). | 3 |
| 5.2 | Photonic devices (Qualitative treatment only) - Light Emitting Diode, Photo detectors (Junction and PIN photodiodes), Solar cells.                                                                              | 3 |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Describe the principle of LASER.
2. Why are metastable levels needed in a LASER?
3. Write a note on intensity modulated sensors.

#### Course Outcome 2 (CO 2):

1. Describe the physical significance of wave function.
2. State HUP for position and momentum.
3. How does the size of a box affect the permitted energy levels of a particle?

#### Course Outcome 3 (CO 3):



1. Determine the number of quantum states in silicon between  $(E_V - kT)$  and  $E_V$  at  $T=300K$ .
2. Describe the concept of Fermi level and its physical significance..
3. Calculate the probability that an energy state above  $E_F$  is occupied by an electron. Let  $T= 300 K$ . Determine the probability that an energy level  $3kT$  above the Fermi energy is occupied by an electron.

**Course Outcome 4 (CO 4):**

1. Describe the variation of Fermi level with temperature in an extrinsic semiconductor.
2. Determine the Fermi level and the max. doping concentration for which the Boltzmann approximation is still valid.
3. Sketch a graph of  $n_0$  versus temperature for an n-type material.

**Course Outcome 5 (CO 5):**

1. Describe the formation of the depletion region.
2. Draw the I-V characteristics of a solar cell..
3. Describe the advantage of a PIN diode over a PN diode when used as a photo detector.

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

SECOND SEMESTER B.TECH DEGREE EXAMINATION, JUNE 2025

**Course Code: B24PH1T01A**

**Course Name: ENGINEERING PHYSICS (A)**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks.**

1. Explain the term population inversion.
2. Describe the principle of operation of optic fibers.
3. State Heisenberg's Uncertainty principle for conjugate variables.
4. Write the time independent Schrodinger equation.
5. What is meant by Fermi level?.
6. Write the Fermi-Dirac distribution function..
7. What are the factors affecting the Fermi level in an extrinsic semiconductor?
8. Plot the variation in  $E_F$  against donor concentration in an n-type semiconductor.
9. Sketch the energy bands in an unbiased, reverse-biased and forward-biased PN junction.
10. What is meant by a space charge region?

**PART B**

**Answer any one question from each module. Each question carries 14 marks.**

1. (a) Define numerical aperture of an optic fiber and derive an expression for the NA of a step index fiber with a neat diagram.. 10
- (b) Calculate the numerical aperture and acceptance angle of a fiber with a core refractive index of 1.54 and a cladding refractive index of 1.50 when the fiber is inside water of refractive index 1.33. 4

OR

2. (a) Outline the construction and working of Ruby laser. 10
  - (b) Calculate the N.A. of an optic fiber having core index of 1.54 and cladding index of 1.5 4
3. (a) Derive time dependent Schrodinger equation. 10
  - (b) An electron is confined to a one dimensional potential box of length  $2\text{\AA}$ . Calculate the energies corresponding to the first and second quantum states in eV. 4

OR

4. (a) Derive the expression for the energy eigenvalues for a particle confined within a box of width L. 10
  - (b) b. Find the de-Broglie wavelength of an electron whose kinetic energy is 15eV. 4
5. (a) Derive the equations for the thermal equilibrium concentrations of electrons and holes in terms of the Fermi energy 10
  - (b) b. Calculate the density of states per unit volume with energies between 0 eV and 1 eV. 4

OR

6. (a) Derive the equation for the intrinsic carrier concentration. 10
  - (b) b. Let  $T=300\text{ K}$ . Determine the probability that an energy level  $3kT$  above the Fermi energy is occupied by an electron 4
7. (a) Derive the fundamental relationship  $n_0 p_0 = n_i^2$ . 10
  - (b) Consider silicon at  $T=300\text{ K}$  and assume that  $N_c = 2.8 \times 10^{19} \text{ cm}^{-3}$  and  $N_v = 1.04 \times 10^{19} \text{ cm}^{-3}$ . Assuming that the Fermi energy is 0.25 eV below the conduction band and that the bandgap energy of silicon is 1.12 eV, determine the type of silicon under consideration. 4

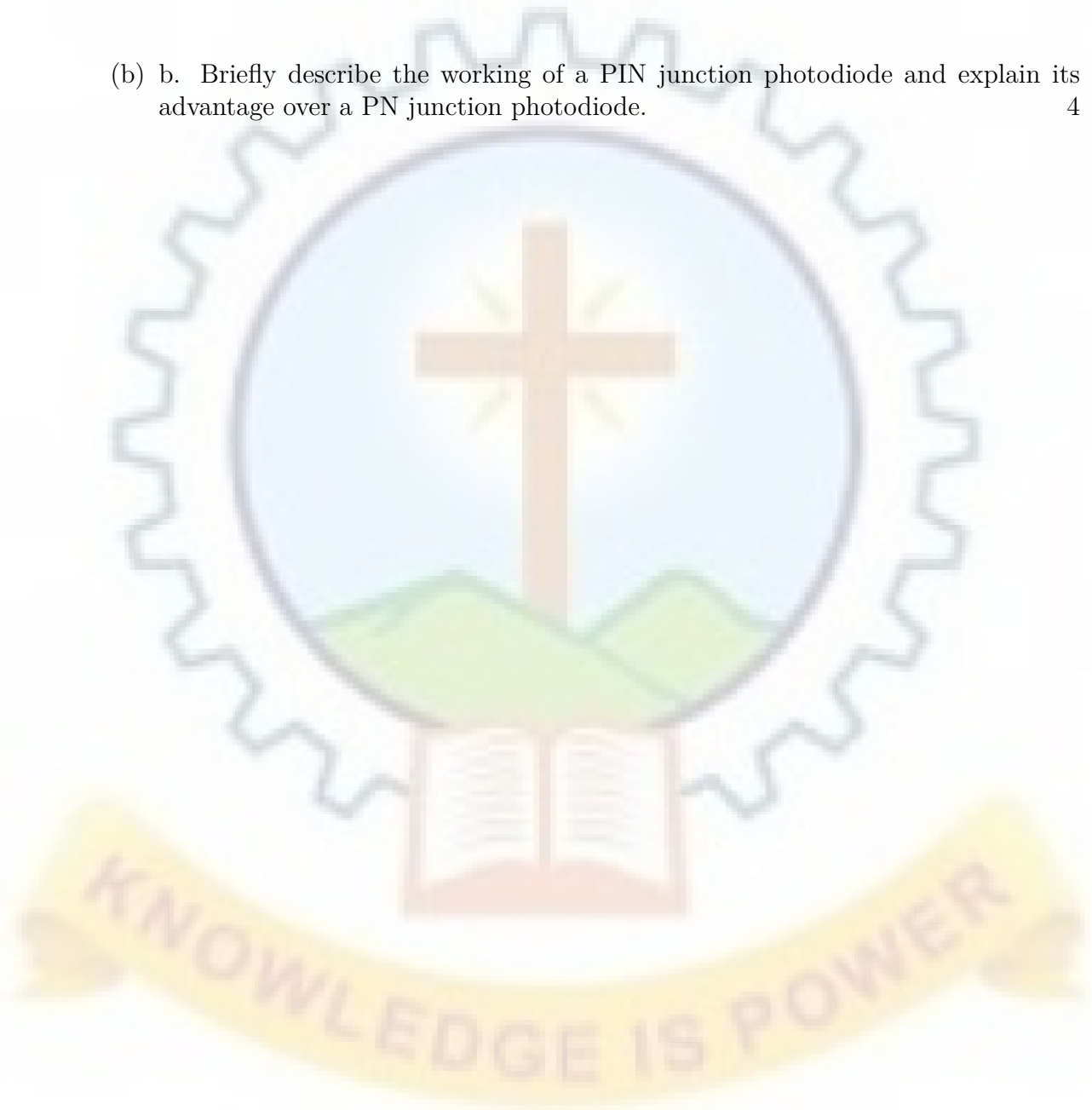
OR

8. (a) Derive the equations for  $n_0$  and  $p_0$  in terms of impurity doping concentrations. 10
  - (b) Silicon at  $T=300\text{ K}$  contains an acceptor impurity concentration of  $N_a = 10^{16} \text{ cm}^{-3}$ . Determine the concentration of donor impurity atoms that must be added so that the silicon is n type and the Fermi level is 0.20 eV below the conduction-band edge. 4
9. (a) Describe the structure of energy bands in a PN junction under zero bias, forward bias and reverse bias and explain why conduction is possible only when it is forward-biased. 10

- (b) b. Write the ideal diode equation and draw the corresponding I-V characteristics.  
4

**OR**

10. (a) Explain the structure of an LED and explain the process of emission of light from the same with the help of the energy band diagram. 10
- (b) b. Briefly describe the working of a PIN junction photodiode and explain its advantage over a PN junction photodiode. 4



| B24CY1T01A | Engineering Chemistry (A) | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|------------|---------------------------|---|---|---|---|--------|----------------------|
|            |                           | 2 | 1 | 0 | 4 |        |                      |

**Preamble:**

This basic science course will assist the students to acquire understanding in the concepts of chemistry for engineering applications and to familiarize the students with different application oriented topics like electrochemistry, nanomaterials, energy production, energy storage, OLED etc. Moreover, the students will be able to know analytical methods like various spectroscopic techniques, SEM etc. This will empower them to develop abilities and skills that are relevant to the study and practice of chemistry in their respective field of engineering.

**Prerequisites:** NIL

**Course Outcomes:**

After the completion of the course the student will be able to:

|             |                                                                                                                                                                                                |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Develop a comprehensive understanding of nanoscale materials, including their synthesis, fundamental properties and diverse applications. (Cognitive Knowledge Level: Apply)                   |
| <b>CO 2</b> | Understand the principles and applications of various spectroscopic techniques and microscopic techniques such as SEM. (Cognitive Knowledge Level: Apply)                                      |
| <b>CO 3</b> | Demonstrate an inclusive understanding of the principles of electrochemistry and corrosion. Also gain knowledge about various corrosion control methods. (Cognitive Knowledge Level: Apply)    |
| <b>CO 4</b> | Learn about the basics of energy harvesting methods and its application. Apply the knowledge of battery, hydrogen generation and fuel cells in engineering. (Cognitive Knowledge Level: Apply) |
| <b>CO 5</b> | Apply the knowledge of conducting polymers and advanced materials in engineering. (Cognitive Knowledge Level: Apply)                                                                           |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 2    | 1    | 1    | 1    | 1    | 1    |      |      | 1    |       | 1     |
| <b>CO 2</b> | 2    | 2    |      | 2    | 1    |      |      |      | 1    |       | 1     |
| <b>CO 3</b> | 2    | 1    |      |      | 1    |      |      |      | 1    |       | 1     |
| <b>CO 4</b> | 2    | 2    | 1    |      | 1    |      |      |      | 1    |       | 1     |
| <b>CO 5</b> | 2    | 1    | 1    | 1    | 1    | 1    |      |      | 1    |       | 1     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                     | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|---------------------|---------------------------------------|
|                  | Test 1<br>(% Marks)   | Test 2<br>(% Marks) |                                       |
| Remember         | 30                    | 30                  | 30                                    |
| Understand       | 50                    | 50                  | 50                                    |
| Apply            | 20                    | 20                  | 20                                    |
| Analyse          |                       |                     |                                       |
| Evaluate         |                       |                     |                                       |
| Create           |                       |                     |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Quiz/Course Project         | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions carrying 3 marks each. Part B contains 2 questions from each module out of which 1 to be answered. Each question carries 14 marks and can have maximum 2 sub divisions.

## SYLLABUS

### MODULE 1 (7 hours)

#### Fundamentals of Nanomaterials

Introduction - Classification - Based on dimension and structural composition - Nanoscale materials – Introduction - Properties and applications of Quantum dots, Graphene and Carbon nanotubes (CNT) – General Properties and applications of nanomaterials - Synthesis



of nanomaterials – Top-Down and Bottom-Up approaches – Physical methods of synthesis - Mechanical milling, Laser ablation and Sputtering - Chemical methods of synthesis – Sol-Gel, co-precipitation and reduction.

## **MODULE 2 (8 hours)**

### **Spectroscopic and Microscopic Techniques**

Introduction - Types of spectrum - Electromagnetic spectrum - Molecular energy levels - Beer-Lambert's law – Numerical problems based on Beer-Lambert's law - Electronic spectroscopy (UV-vis) – Principle, instrumentation and applications - Types of electronic transitions - Vibrational spectroscopy (IR) – Principle and applications - Number of vibrational modes - Vibrational modes of  $CO_2$  and  $H_2O$  – Force constant equation for diatomic molecules - Numerical problems based on force constant - Microscopic techniques - Scanning Electron Microscope (SEM) - Principle, instrumentation, working and applications.

## **MODULE 3 (7 hours)**

### **Introduction to Electrochemistry and Corrosion Science**

Introduction - Reference electrodes - Calomel electrode - Construction and working - Electrochemical series - Applications – Nernst equation for single electrode and cell (Derivation not required) – Applications – Effect of temperature on emf - Numerical problems based on Nernst equation - Corrosion – Introduction - Galvanic series - Types of corrosion – Galvanic and pitting corrosion - Corrosion control methods - Cathodic protection - Sacrificial anodic protection and impressed current cathodic protection – Electroplating of Copper - Electroless plating of Copper – Anodizing of Aluminium.

## **MODULE 4 (7 hours)**

### **Energy Storage and Harvesting Technologies**

Cells and batteries – Primary and secondary cells – Na-ion battery and Li-ion battery - Construction, working, advantages and applications – Hydrogen generation – Electrolysis of water - Fuel cells – Introduction - Construction and advantages of  $H_2$ - $O_2$  fuel cell, Phosphoric acid fuel cell and Polymer Electrolyte Membrane Fuel Cell (PEMFC) - Supercapacitors - Classification - Construction and applications in hybrid vehicles.

## **MODULE 5 (7 hours)**

### **Advanced Materials and Devices for Engineering Applications**

Conducting polymers – Introduction - Classification - Intrinsically and extrinsically conducting polymers - Conduction mechanism – Band theory - Polyaniline and polypyrrole - Synthesis, properties and applications – Molecular devices based on conducting polymers – Diodes, Field Effect Transistor and Actuators - Introduction and applications - OLED – Construction, working and advantages - Smart materials - Thermo and light responsive materials - Introduction and examples - Sensors – Physical, chemical and biosensors – Introduction and applications.

### **Text Books**

1. Jain and Jain, "Engineering Chemistry", Dhanpat Rai Publishing Company, 17<sup>th</sup> edition 2015.
2. Shashi Chawla, "A Text Book of Engineering Chemistry", Dhanpat Rai and Co. (P) Limited, 2017.
3. Muhammed Arif, Annette Fernandez, Kavitha P. Nair, "Engineering Chemistry", Owl Books, 2019.
4. Ahad J., "Engineering Chemistry", Jai Publication, 2019.
5. Roy K. Varghese, "Engineering Chemistry", Crown Plus Publishers, 2019.
6. Soney C. George, Rino Laly Jose, "Text Book of Engineering Chemistry", S. Chand and Company Pvt. Ltd., 2019.
7. B. L. Tembe, Kamaluddin, M. S. Krishnan, "Engineering Chemistry (NPTEL Web Book)", 2018.

### **Reference Books**

8. T. Pradeep, "NANO: The Essentials: Understanding Nanoscience and Nanotechnology", McGraw-Hill, 2008.
9. B. Rogers, J. Adams, S. Pennathur, "Nanotechnology: Understanding Small Systems", CRC Press, 2014.
10. Donald L. Pavia, "Introduction to Spectroscopy", Cengage Learning India Pvt. Ltd., 2015.
11. J. Goldstein, "Scanning Electron Microscopy and Microanalysis", Springer, 2012.
12. H. H. Willard, L. L. Merritt, "Instrumental Methods of Analysis", CBS Publishers, 7<sup>th</sup> Edition, 2005.
13. Samuel Glasstone, "An Introduction to Electrochemistry", East-West Press Pvt. Ltd., 2006.
14. Pietro Pedferri, "Corrosion Science and Engineering", Springer Link, 2018.
15. B. Sunden, "Hydrogen, Batteries and Fuel Cells", Elsevier Inc., 2019.
16. B. Sorensen and G. Spazzafumo, "Hydrogen and Fuel Cells - Emerging Technologies and Applications", Elsevier Ltd., 2018.
17. Raymond B. Seymour, Charles E. Carraher, "Polymer Chemistry: An Introduction", Marcel Dekker Inc; 4<sup>th</sup> Revised Edition, 1996.
18. J. Janata, "Principles of Chemical Sensors" Springer, New York, NY, 2009.
19. F-G. Banica, "Chemical Sensors and Biosensors: Fundamentals and Applications", John Wiley and Sons, 2012.

20. M. Schwartz, "Smart Materials", CRC Press, 2008.
21. Y. Zhao, T. Ikeda, "Smart Light-Responsive Materials", Wiley, 2009.
22. V. Khutoryanskiy, T. Georgiou, "Temperature-Responsive Polymers: Chemistry, Properties and Applications", Wiley, 2018.
23. P. W. Atkins, "Physical Chemistry", Oxford University Press, 10<sup>th</sup> edn., 2014.

### **COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                                                                                                                                                                                                                                                        | <b>No of Lecture/Tutorial Hours</b> |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | Total Hours                                                                                                                                                                                                                                                                                                                                         | 36 Hours                            |
|           | <b>Module 1 (Fundamentals of Nanomaterials)</b>                                                                                                                                                                                                                                                                                                     | 7                                   |
| 1.1       | Introduction - Classification - Based on dimension and structural composition.                                                                                                                                                                                                                                                                      | 1                                   |
| 1.2       | Nanoscale materials – Introduction - Properties and applications of Quantum dots, Graphene and Carbon nanotubes (CNT) – General properties and applications of nanomaterials.                                                                                                                                                                       | 3                                   |
| 1.3       | Synthesis of nanomaterials – Top-Down and Bottom-Up approaches – Physical methods of synthesis - Mechanical milling, Laser ablation and Sputtering - Chemical methods of synthesis – Sol-Gel, co-precipitation and reduction.                                                                                                                       | 3                                   |
|           | <b>Module 2 (Spectroscopic and Microscopic Techniques)</b>                                                                                                                                                                                                                                                                                          | 8                                   |
| 2.1       | Introduction - Types of spectrum - Electromagnetic spectrum - Molecular energy levels - Beer-Lambert's law – Numerical problems based on Beer-Lambert's law.                                                                                                                                                                                        | 3                                   |
| 2.2       | Electronic spectroscopy (UV-vis) – Principle, instrumentation and applications - Types of electronic transitions - Vibrational spectroscopy (IR) – Principle and applications - Number of vibrational modes - Vibrational modes of $CO_2$ and $H_2O$ – Force constant equation for diatomic molecules - Numerical problems based on force constant. | 4                                   |
| 2.3       | Microscopic techniques - Scanning Electron Microscope (SEM) - Principle, instrumentation, working and applications.                                                                                                                                                                                                                                 | 1                                   |
|           | <b>Module 3 (Introduction to Electrochemistry and Corrosion Science)</b>                                                                                                                                                                                                                                                                            | 7                                   |

|     |                                                                                                                                                                                                                                                                                                   |   |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 3.1 | Introduction - Reference electrodes - Calomel electrode - Construction and working - Electrochemical series - Applications - Nernst equation for single electrode and cell (Derivation not required) - Applications - Effect of temperature on emf - Numerical problems based on Nernst equation. | 3 |
| 3.2 | Corrosion - Introduction - Galvanic series - Types of corrosion - Galvanic and pitting corrosion - Corrosion control methods - Cathodic protection - Sacrificial anodic protection and impressed current cathodic protection.                                                                     | 2 |
| 3.3 | Electroplating of Copper - Electroless plating of Copper - Anodizing of Aluminium                                                                                                                                                                                                                 | 2 |
|     | <b>Module 4 (Energy Storage and Harvesting Technologies)</b>                                                                                                                                                                                                                                      | 7 |
| 4.1 | Cells and batteries - Primary and secondary cells - Na-ion battery and Li-ion battery - Construction, working, advantages and applications.                                                                                                                                                       | 2 |
| 4.2 | Hydrogen generation - Electrolysis of water - Fuel cells - Introduction - Construction and advantages of $H_2$ - $O_2$ fuel cell, Phosphoric acid fuel cell and Polymer Electrolyte Membrane Fuel Cell (PEMFC).                                                                                   | 3 |
| 4.3 | Supercapacitors - Classification - Construction and applications in hybrid vehicles.                                                                                                                                                                                                              | 2 |
|     | <b>Module 5 (Advanced Materials and Devices for Engineering Applications)</b>                                                                                                                                                                                                                     | 7 |
| 5.1 | Conducting polymers - Introduction - Classification - Intrinsically and extrinsically conducting polymers - Conduction mechanism - Band theory - Polyaniline and polypyrrole - Synthesis, properties and applications.                                                                            | 3 |
| 5.2 | Molecular devices based on conducting polymers - Diodes, Field Effect Transistors, and Actuators - Introduction and applications - OLED - Construction, working and advantages.                                                                                                                   | 2 |
| 5.3 | Smart materials - Thermo and light responsive materials - Introduction and examples - Sensors - Physical, chemical and biosensors - Introduction and applications.                                                                                                                                | 2 |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. What are carbon nanotubes? Give two applications.
2. Comment on the structure of graphene.
3. How nanomaterials are classified based on structural composition?

**Course Outcome 2 (CO 2):**

1. State Beer-Lambert's law.
2. Calculate and sketch the vibrational modes of  $CO_2$ .
3. What are the limitations of SEM?

**Course Outcome 3 (CO 3):**

1. How equilibrium constant is determined using electrochemical series?
2. Write the representation and reactions of calomel electrode.
3. Give any two differences between electrochemical series and galvanic series.

**Course Outcome 4 (CO 4):**

1. Compare Na-ion and Li-ion batteries.
2. List the applications of PEM fuel cell.
3. Discuss the classification of supercapacitors.

**Course Outcome 5 (CO 5):**

1. Explain the preparation and properties of polypyrrole.
2. Discuss the working of OLED.
3. Compare physical and chemical sensors.



MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

FIRST SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2024

**Course Code: B24CY1T01A**

**Course Name: ENGINEERING CHEMISTRY (A)**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks.**

1. Discuss the properties and applications of quantum dots.
2. How carbon nanotubes are classified based on structure?
3. State Beer-Lambert's law.
4. List the important applications of IR spectroscopy.
5. Explain how galvanic series can be used in corrosion control?
6. What is calomel electrode? Give the reduction reaction.
7. How does a PEM fuel cell differ from the other types of fuel cells?
8. Distinguish between primary and secondary cells with examples.
9. Give example and explain the importance of light responsive smart materials.
10. What are biosensors? Give their applications.

**PART B**

**Answer any one question from each module. Each question carries 14 marks.**

11. (a) Explain two methods of chemical synthesis for nanomaterials. 8



- (b) Discuss the classification of nanomaterials based on dimension. 6

**OR**

12. (a) What are nanoscale materials? Give the properties and applications of quantum dots and graphene. 9  
(b) Explain the sputtering method for the synthesis of nanomaterials. 5
13. (a) Explain the principle, instrumentation and working of SEM. 8  
(b) Calculate the force constant of HCl molecule, if it shows IR absorption at  $2138\text{ cm}^{-1}$ . Given that atomic masses of hydrogen and chlorine are 1 u and 35 u respectively. 6

**OR**

14. (a) Illustrate the vibrational modes of  $\text{CO}_2$  and  $\text{H}_2\text{O}$ . Justify its IR activity. 9  
(b) Explain the various energy levels associated with a molecule. 5
15. (a) How electroless plating of copper is carried out? Give the procedure and reactions. 8  
(b) Write the cell reactions and calculate the emf of the cell  $\text{Cu}/\text{Cu}^{2+} (1\text{M}) // \text{Ag}^+ (0.01\text{M}) // \text{Ag}$  at  $30^\circ\text{C}$ . Given  $E^0 \text{Cu}^{2+}/\text{Cu} = 0.34\text{ V}$  and  $E^0 \text{Ag}^+/\text{Ag} = 0.8\text{V}$ . 6

**OR**

16. (a) What is cathodic protection? Explain two methods. 9  
(b) Write the Nernst equation for Daniel cell and explain the effect of temperature on emf. 5
17. (a) Discuss the construction, working and advantages of Li-ion battery. 9  
(b) What is electrolysis of water? 5

**OR**

18. (a) With a neat diagram explain the construction and working of Hydrogen-Oxygen fuel cell. 8  
(b) Explain the classification of supercapacitors. 6
19. (a) Discuss the construction and working of OLED with a diagram. 9  
(b) Explain the synthesis, properties and applications of polyaniline. 5

**OR**

20. (a) Elaborate the classification and applications of conducting polymers. 8  
(b) What are smart materials? Give examples for heat responsive materials. 6

| B24ES1T02 | BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|--------------------------------------------------|---|---|---|---|--------|----------------------|
|           |                                                  | 2 | 2 | 0 | 5 | 4      | 2024                 |

### Preamble

This course aims to provide fundamentals of circuit analysis, electrical components, machines, power systems, and safety practices. It also provide an overview of evolution of electronics, and introduce the working principle and examples of fundamental electronic devices and circuits. Course also aims to provide an introduction to digital electronics. Completing the course, students gain the necessary knowledge for more advanced courses and practical applications

### Prerequisites

Nil

### Course Outcomes

After the completion of the course the student will be able to:

|      |                                                                                                                                                                               |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Understand the essential circuit components and the fundamental circuit laws governing electrical circuits. (Cognitive Knowledge Level: Understand)                           |
| CO 2 | Recall the basics of electromagnetism and the fundamentals of electrical machines and three-phase systems. (Cognitive Knowledge Level: Understand)                            |
| CO 3 | Apply the basic knowledge of household wiring components and analyze electrical wiring layout for small residential buildings. (Cognitive Knowledge Level: Apply)             |
| CO 4 | Identify the active and passive electronic component and their specifications (Cognitive Knowledge Level: Understand)                                                         |
| CO 5 | Design and analyze Rectifiers and Voltage amplifiers (Cognitive Knowledge Level: Apply)                                                                                       |
| CO 6 | Explain the elements of digital system abstractions such as digital representations of information, digital logic and Boolean algebra (Cognitive Knowledge Level: Understand) |

## Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 3    | 2    | 1    |      | 1    | 1    | 1    | 1    | 1     | 1     |
| CO 2 | 3    | 3    | 2    | 1    |      | 1    | 1    | 1    | 1    | 1     | 1     |
| CO 3 | 3    | 2    | 2    | 1    |      | 1    | 1    | 1    | 1    | 1     | 1     |
| CO 4 | 2    | 1    | 1    |      |      |      |      |      |      |       | 1     |
| CO 5 | 2    | 1    | 1    |      |      |      |      |      |      |       | 1     |
| CO 6 | 2    | 1    | 1    |      |      |      |      |      |      |       | 1     |

## Assessment Pattern

|                  | BASIC ELECTRICAL      |                 |                                    | BASIC ELECTRONICS     |                 |                                    |
|------------------|-----------------------|-----------------|------------------------------------|-----------------------|-----------------|------------------------------------|
| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) | Continuous Assessment |                 | End Semester Examination (% Marks) |
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 15                    | 15              | 15                                 | 15                    | 15              | 15                                 |
| Understand       | 20                    | 20              | 20                                 | 25                    | 25              | 25                                 |
| Apply            | 15                    | 15              | 15                                 | 10                    | 10              | 10                                 |
| Analyse          |                       |                 |                                    |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |                       |                 |                                    |
| Create           |                       |                 |                                    |                       |                 |                                    |

## Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

## Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Quiz/Course Project         | 10 marks |
| Self Study                             | 5 marks  |

## **End Semester Examination Pattern**

There will be two parts; Part I – Basic Electrical Engineering and Part II – Basic Electronics Engineering. Part I and PART II carries 50 marks each. For the end semester examination, part I contain 2 parts - Part A and Part B. Part A contain 5 questions carrying 4 marks each (not exceeding 2 questions from each module). Part B contains 2 questions from each module out of which one to be answered. Each question carries 10 mark and can have maximum 2 subdivisions. The pattern for end semester examination for part II is same as that of part I.

## **SYLLABUS**

### **MODULE 1 (7 hours)**

#### **DC Electric Circuits**

Passive components - R, L, and C, Sources - current and voltage sources, Resistances in series and parallel, current and voltage division rule, Ohm's Law, Kirchoff's Laws (Numerical problems).

#### **Alternating Current Fundamentals**

Generation of single-phase voltage - frequency, time period, average value, RMS value (sine wave concept only), Form and peak factors-Phasor representation of R,L,C, RL, RC, and RLC circuits - concept of impedance, power - active, reactive, and apparent, power factor (Numerical problems).

### **MODULE 2 (8 hours)**

#### **DC Machines and Transformers**

Faraday's laws, Lenz's law, statically and dynamically induced EMF. DC Generator- construction and working principle, types, applications. DC motor - working principle, types of DC motors, applications. Transformer (single-phase only) - Construction, types-Working principle. Construction types

#### **Three-Phase AC Systems**

Generation of three-phase voltages - phase sequence, Y- $\Delta$  connection (balanced only), relation between line and phase quantities, three-phase power, Single line diagram of a power system from generation to distribution.

### **MODULE 3 (8 hours)**

#### **Electrical wiring design**

Electrical wiring system in domestic building - types of wiring, cables, Conduits, Switches and Outlets, switch boards, and distribution boards. Common power ratings of domestic

gadgets, Codes and standards- Salient features of NEC, NBC and IE rule, NEC Symbols used in electrical wiring layout. Electrical lay out (single line diagram) for low- class domestic installation. Electrical load calculation- connected load method (Numerical problems).

### **Electrical Installation in Buildings**

Protection devices - MCB, MCCB, ELCB/RCCB and RCBO- Principle of Operation-Rating and Specification, fuses-working and types. Electrical hazards and safety Precautions- Earthing & need of earthing, types.

## **MODULE 4 (8 hours)**

### **Introduction to Electronics Components**

Overview of the Evolution and Applications of Electronics. Familiarization of basic electronic components: Resistors, Capacitors, Inductors: Types, Specifications, Standard values, Color Coding.

### **Introduction to Semiconductor devices**

Understanding PN Junction diode: Structure and Principle of Operation, V-I Characteristics, Diode Current equation (Simple problems), Special Diode: Zener Diode, Break down mechanisms, Bipolar junction Transistor: NPN and PNP Structure, Principle of operation of NPN Transistor

## **MODULE 5 (7 hours)**

### **Introduction to Basic electronic circuits:**

Rectifiers and power supplies: Block diagram description of a dc power supply, working of a full wave bridge rectifier, capacitor filter (no analysis), working of simple Zener voltage regulator, Input and Output Characteristics of Common Emitter Configuration, Amplifier: RC Coupled Amplifier using Voltage divider bias- Frequency Response-Bandwidth

## **MODULE 6 (7 hours)**

### **Introduction to Digital Electronics**

Number Systems: Decimal, Binary, Octal, and Hexadecimal number systems, Number Base Conversions, Binary Arithmetic: Addition, Subtraction, Multiplication, Logic gates, Universal Gates, Truth table, Realization of NOT gate using transistor

### **Text Books**

1. D. P. Kothari and I. J. Nagrath, "Basic Electrical Engineering," 3<sup>rd</sup> Edition, Tata McGraw Hill."Electric Circuits & Networks", Pearson Education, 2009.
2. J. B. Gupta, "Theory and Performance of Electrical Machines" 15<sup>th</sup> Edition, S. K. Katarina & Sons.
3. M.K. Giridharan, Electrical System Design.



4. Chinmoy Saha, Arindham Halder and Debarati Ganguly, Basic Electronics - Principles and Applications, Cambridge University Press, 2018.
5. M.S.Sukhija and T.K.Nagsarkar, Basic Electrical and Electronics Engineering, Oxford University Press, 2012.

### Reference Books

1. C. L. Wadhwa, "Basic Electrical Engineering," 4<sup>th</sup> Edition, New Age International Publisher
2. V. N. Mittle, "Basic Electrical Engineering," Tata McGraw Hill.
3. V. K. Mehta & Rohit Mehta, "Principles of Electrical Engineering," 6<sup>th</sup> Edition, S. Chand & Co. PVT. LTD
4. S. K. Bhattacharya, "Basic Electrical and Electronics Engineering," 2<sup>nd</sup> Edition, Pearson Education.
5. D C Kulshreshtha, "Basic Electrical Engineering," 2<sup>nd</sup> Edition Tata McGraw Hill.
6. Del Toro V, "Electrical Engineering Fundamentals," 2<sup>nd</sup> Edition, New Delhi Prentice Hall of India.
7. Hughes, "Electrical and Electronic Technology", 10<sup>th</sup> Edition, Pearson Education.
8. R. K. Rajput, "Basic Electrical Engineering," 2<sup>nd</sup> Edition, Laxmi Publications PVT. LTD
9. Anant Agarwal, Jeffrey Lang, Foundations of Analog and Digital Electronic Circuits, Morgan Kaufmann Publishers, 2005.
10. Bernard Grob, Basic Electronics, McGraw Hil

### COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                         | No of Lecture/Tutorial Hours |
|-----|-----------------------------------------------------------------------------------------------|------------------------------|
|     | Total Hours                                                                                   | 45 Hours                     |
|     | <b>Module 1: DC Electric Circuits &amp; Alternating Current Fundamentals:</b>                 | 7                            |
| 1.1 | DC Electric Circuits: Passive Components - R, L, and C, sources - current and voltage sources | 1                            |
| 1.2 | Resistances in series and parallel, current and voltage division rule (Numerical problems).   | 1                            |
| 1.3 | Ohm's Law, Kirchoff's Laws (Numerical problems).                                              | 2                            |



|     |                                                                                                                                                                            |     |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 1.4 | Alternating Current Fundamentals: Representation of sinusoidal waveforms - frequency, time period, average value, RMS value.                                               | 1   |
| 1.5 | Phasor representation of R, RL, RC, RLC circuits - concept of impedance, power - active, reactive and apparent, power factor (Numerical problems).                         | 2   |
|     | <b>Module 2:DC Machine and Three-Phase AC Systems:</b>                                                                                                                     | 8 . |
| 2.1 | Electromagnetic Induction: Faraday's laws, Lenz's law, statically and dynamically induced EMF                                                                              | 1   |
| 2.2 | DC Machines: Construction and working principle - DC Generator – Types-applications.                                                                                       | 2   |
| 2.3 | DC motor - Construction and working principle- Types-applications                                                                                                          | 1   |
| 2.4 | Transformers (single phase only): Working principle.                                                                                                                       | 1   |
| 2.5 | Three-Phase AC Systems: Generation of three-phase voltages - phase sequence.                                                                                               | 1   |
| 2.6 | Y- $\Delta$ connection (balanced only), relation between line and phase quantities, three phase power.                                                                     | 2   |
|     | <b>Module 3: Electrical wiring design &amp; Electrical Installation in Buildings:</b>                                                                                      | 8   |
| 3.1 | Electrical wiring design: Electrical wiring system in domestic building - types of wiring, cables, Conduits, Switches and Outlets, switch boards, and distribution boards. | 1   |
| 3.2 | Common power ratings of domestic gadgets, Codes and standards- Salient features of NEC, NBC and IE rule, NEC Symbols used in electrical wiring layout.                     | 1   |
| 3.3 | Electrical lay out (single line diagram) for low- class domestic installation. Electrical load calculation- connected load method (Numerical problems).                    | 2   |
| 3.4 | Electrical Installation in Buildings: Protection devices - MCB, MCCB, ELCB/RCCB and RCBO- Principle of operation, fuses-working and types                                  | 2   |
| 3.5 | Electrical hazards and safety precautions-Earthing & need of earthing, types, Electrical Safety & Precautions                                                              | 2   |
| 3.6 | Average value, rms value, form and peak factors of trapezoidal and sinusoidal waveforms - Numerical problems.                                                              | 2   |
| 3.7 | Phasor representation of sinusoidal quantities - phase difference, addition and subtraction of sinusoids.                                                                  | 1   |
| 3.8 | Symbolic Representation: cartesian, polar and exponential forms.                                                                                                           | 1   |
|     | <b>Module 4: Introduction to Semiconductor devices</b>                                                                                                                     | 8   |
| 4.1 | Overview of the Evolution and Applications of Electronics.                                                                                                                 | 1   |
| 4.2 | Familiarization of basic electronic components: Resistors, Capacitors, Inductors: Types, Specifications, Standard values, Color Coding.                                    | 3   |

|     |                                                                                                                                                                                                    |   |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 4.3 | Understanding PN Junction diode: Structure and Principle of Operation                                                                                                                              | 1 |
| 4.4 | V-I Characteristics, Diode Current equation (Simple problems)                                                                                                                                      | 1 |
| 4.5 | Special Diode: Zener Diode, Break down mechanisms                                                                                                                                                  | 1 |
| 4.6 | Bipolar junction Transistor : NPN and PNP Structure, Principle of operation of NPN Transistor                                                                                                      | 1 |
|     | <b>Module 5: Introduction to Basic electronic circuits:</b>                                                                                                                                        | 7 |
| 5.1 | Rectifiers and power supplies: Block diagram description of a dc power supply, Working of a full wave bridge rectifier, capacitor filter (no analysis), working of simple Zener voltage regulator. | 4 |
| 5.2 | Input and Output Characteristics of Common Emitter Configuration                                                                                                                                   | 1 |
| 5.3 | Amplifier: RC Coupled Amplifier using Voltage divider bias- Frequency response-Bandwidth .                                                                                                         | 2 |
|     | <b>Module 6: Introduction to Digital Electronics:</b>                                                                                                                                              | 7 |
| 6.1 | Number Systems: Decimal ,Binary, Octal, and Hexadecimal number systems, Number Base Conversions                                                                                                    | 2 |
| 6.2 | Binary Arithmetic : Addition, Subtraction, Multiplication                                                                                                                                          | 2 |
| 6.3 | Logic gates, Universal Gates, Truth table .                                                                                                                                                        | 2 |
| 6.4 | Realization of NOT gate using transistor .                                                                                                                                                         | 1 |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Solve problems based on series and parallel circuits.
2. Solve problems based on current and voltage division rules.
3. Solve problems using Kirchoff's laws.
4. Phasor representation of R, RL, RC and RLC circuits.
5. Problems on rms and average values of periodic waveforms.
6. Problems related to power and power factor.

#### Course Outcome 2 (CO 2):

1. Construction and working of DC generator and DC motor.
2. Different types and applications of DC generator and DC motor.

3. Working principle of single-phase transformer.
4. Problems on three-phase line & phase quantities for a balanced load.

**Course Outcome 3 (CO 3):**

1. Electrical wiring system in domestic building.
2. Codes and standards .
3. Electrical lay out (single line diagram).
4. Electrical load calculation- connected load method (Numerical problems).
5. Protection devices and its principle of operation.
6. Electrical hazards and safety Precautions-Earthing & need of earthing, types, Electrical Safety & Precautions.

**Course Outcome 4 (CO 4):**

1. Explain the significance of color coding in identifying the values of resistors.
2. Describe the structure of a PN junction diode and its principle of operation
3. Describe the structure of a PN junction diode and its principle of operation

**Course Outcome 5 (CO 5):**

1. What is the need of voltage divider biasing in an RC coupled amplifier?
2. Analyze the importance of selection of operating point in the context of a BJT amplifier.
3. Why is it required to have a voltage amplifier in a public address system?

**Course Outcome 6 (CO 6):**

1. Convert 203:5210 to binary and hexadecimal.
2. Implement an AND gate using NOR gate.
3. Define logic gates and explain their fundamental role in digital electronics.

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg.No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

FIRST SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: : B24ES1T02

Course Name: BASICS OF ELECTRICAL ENGINEERING

Max. Marks: 100

Duration: 3 hours

**PART 1: BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**PART A**

**Answer all questions. Each question carries 4 marks.**

1. State and explain Kirchhoff's laws with examples.
2. Differentiate between statically and dynamically induced emf.
3. Derive the relation between line and phase current in a 3-phase delta-connected system.
4. Distinguish between MCB and MCCB.
5. What is the need for earthing? Describe the different types of earthing.

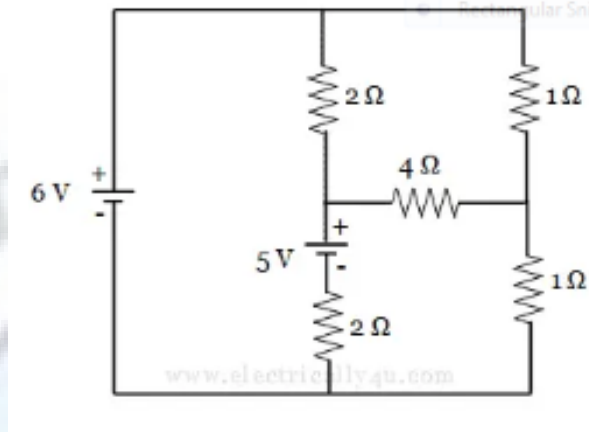
**PART B**

**Answer any one full question . Each question carries 10 marks.**

6. A resistance of  $10\Omega$  and inductance of  $0.3H$  and a capacitance of  $100 F$  are connected in series across  $230V$ ,  $50Hz$  single-phase supply. Calculate the 10
  - (a) Impedance of the circuits
  - (b) Current through the circuits
  - (c) Voltage across  $R$ ,  $L$ , and  $C$
  - (d) Power consumed by the circuit.

OR

7. For the circuit shown below, determine the current flows through all the resistors using Kirchoff's law. 10



8. A 3-phase, 400V, 4 wire system has a balanced star connected load with impedance  $Z=15+j10 \Omega$  each. Find the line currents and the total power consumed by the load. 10

OR

9. (a) State Faraday's laws of electromagnetic induction. 4  
(b) Explain the construction and working principle of DC motor. 6
10. What is the role of NEC and NBC in building design? 10

OR

11. (a) Explain the different types of wiring. 5  
(b) What are the different NEC symbols used in electrical wiring layout? 5

## PART 2: BASICS OF ELECTRONICS ENGINEERING

### PART A

**Answer all questions. Each question carries 4 marks.**

1. (a) Identify the colour code for the given resistor values.  
i.  $1\Omega + 5$   
ii.  $3.3k\Omega + 1$   
(b) Identify the capacitor value with unit.
2. Explain the break down mechanisms of Zener diode

3. Briefly Discuss the block diagram of a DC power supply.
4. For a NPN transistor  $\alpha=0.98$  and  $I_B=100$  A . Find  $I_E$  and  $I_C$
5. Which gates are called universal gates and why?

**PART B**

**Answer any one full question . Each question carries 10 marks.**

6. (a) Explain with necessary diagrams the principle of operation of NPN transistor 5  
(b) Write the diode current equation, If the reverse saturation current of Germanium diode at room temperature is 0.4 micro ampere. Determine the current flowing through the diode when 0.2V is applied at room temperature. 5

**OR**

7. (a) Plot and explain the V-I characteristics of a PN junction Diode 5  
(b) Describe the color coding of a resistor with suitable example. 5
8. With necessary diagrams explain the working of a full wave bridge rectifier 10

**OR**

9. Describe the input and output characteristics of Common emitter configuration. 10
10. Convert the following numbers to binary 10
  - (a)  $EE9_{16}$
  - (b)  $FD654_{16}$
  - (c)  $33_{10}$
  - (d)  $17_{10}$
  - (e)  $1142_8$

**OR**

11. Draw the symbol and truth table of AND, OR, NAND, NOR and XOR 10



| <b>B24ES1L02</b> | <b>BASIC ELECTRICAL AND ELECTRONICS WORKSHOP</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF INTRODUCTION</b> |
|------------------|--------------------------------------------------|----------|----------|----------|----------|---------------|-----------------------------|
|                  |                                                  | 0        | 0        | 2        | 1        | 1             | 2024                        |

**Preamble**

The course aims to impart fundamentals of electrical wiring, safety measures, and troubleshooting to students. The course will expose student to the concepts various wiring methods and distribution systems. It also gives the basic introduction of electronic hardware systems and provides hands-on training with familiarization, identification, testing, assembling, dismantling, fabrication and repairing such systems by making use of the various tools and instruments available in the Electronics Workshop.

**Prerequisite**

Nil

**Course Outcomes**

After the completion of the course the student will be able to

|             |                                                                                                                                                                                                                                     |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Identify electrical symbols, measuring instruments, accessories, and tools used for electrical wiring. (Cognitive Knowledge Level: Apply)                                                                                           |
| <b>CO 2</b> | Understand the substation, distribution system, and safety measures against electrical shocks and select the fuse unit for a given electrical circuit.(Cognitive Knowledge Level – Understand)                                      |
| <b>CO 3</b> | Estimate and develop the electric circuits for wiring domestic and industrial buildings. .(Cognitive Knowledge Level – Apply)                                                                                                       |
| <b>CO 4</b> | Demonstrate proficiency in identifying various electronic components, including active, passive, electrical, electronic, and electromechanical components (Cognitive Knowledge Level-Understand)                                    |
| <b>CO 5</b> | Develop and illustrate electronic circuit diagrams using recognized standards such as BIS/IEEE symbols and utilize Electronic Design Automation (EDA) tools for schematic capture and simulation. (Cognitive Knowledge Level-Apply) |
| <b>CO 6</b> | Design and fabricate electronic circuits on boards, trouble shooting of minor problems in electronic equipment and handling of test and measuring equipment (Cognitive Knowledge Level-Apply)                                       |

**Mapping of Course Outcomes With Program Outcomes**

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    | 3    | 1    |      | 3    | 1    | 3    | 3    | 2     | 3     |
| CO 2 | 3    | 2    | 3    | 1    |      | 3    | 1    | 3    | 3    | 2     | 3     |
| CO 3 | 3    | 3    | 3    | 3    |      | 3    | 1    | 3    | 3    | 3     | 3     |
| CO 4 | 3    | 1    | 1    | 1    |      |      |      | 1    | 1    |       | 2     |
| CO 5 | 3    | 2    | 2    | 1    | 2    |      |      | 2    | 1    |       | 2     |
| CO 6 | 3    | 2    | 2    | 1    | 2    |      |      | 2    | 1    |       | 1     |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 70        | 30        | 1 hour       |

### Continuous Internal Evaluation Pattern

|                                  |          |
|----------------------------------|----------|
| Attendance                       | 20 marks |
| Class Work/ Assessment Viva-Voce | 50 marks |
| Viva voce / test                 | 30 marks |

### End Semester Examination Pattern

The college will internally conduct end semester examination. Separate ESE 's will be held for Electrical workshop and Electronics workshops, each in the form of a one-hour written / objective exam. The total marks for this course is equally divided between the Electrical and Electronics workshop.

## SYLLABUS

### LIST OF EXPERIMENTS PART I

#### ELECTRICAL

|   |                                                                                                                                                                                                                                                                                          |
|---|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | <p>a) Familiarization with electrical symbols, measuring instruments, lighting and wiring accessories, tools, and various wiring systems.</p> <p>b) Familiarization with earthing in electrical installations ,precautions against electric shock phenomenon and safety procedures .</p> |
|---|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|          |                                                                                                                                                                                                                          |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>2</b> | Realization of domestic wiring<br><br>a) Wiring of one lamp controlled by one switch and a 3-pin plug socket controlled independently.<br><br>b) Wiring of one lamp controlled by two switches (Staircase wiring).       |
| <b>3</b> | a) Realization of Industrial wiring - Wiring of three lamps controlled by three switches (Godown wiring).<br><br>b) Study of fuse, MCB, ELCB, RCCB and selection of fuse rating for circuits with medium and high power. |
| <b>4</b> | Wiring of the distribution board, including the power plug, an isolator, MCB, and ELCB for 1000 W power.                                                                                                                 |
| <b>5</b> | Measurement of low-medium-high resistance using the megger and voltmeter-ammeter method.                                                                                                                                 |
| <b>6</b> | Visit the on-campus substation and familiarize with the supply system, transformer, HT Panel, and distribution system.                                                                                                   |

### Reference Books

1. H Cotton, Advanced Electrical Technology, Reem Publications, 2011.
2. Suresh Kumar K.S, Electrical Circuit and Networks, Pearson Education, New Delhi, 2009.
3. EW. Golding, Electrical Measurements and Measuring Instruments, 5<sup>th</sup> ed. Reem Publications, 2011.
4. A course in electrical installation estimating and costing, J Bh Gupta, 9<sup>th</sup> edition, 2012

## PART II ELECTRONICS

|   |                                                                                                                                                                                                                                                                                                                                                                                                                     |
|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Familiarization/Identification of electronic components with specification (Functionality, type, size, colour coding, package, symbol, cost etc. [Active, Passive, Electrical, Electronic, Electro-mechanical, Wires, Cables, Connectors, Fuses, Relays, Crystals, Displays, Heat sink etc.) .                                                                                                                      |
| 2 | Drawing of electronic circuit diagrams using BIS/IEEE symbols and introduction to EDA tools (such as Dia ,XCircuit, LT SPICE).                                                                                                                                                                                                                                                                                      |
| 3 | Familiarization/Application of testing instruments and commonly used tools. [Multimeter, Function generator, Power supply, DSO etc.] [Soldering iron, Desoldering pump, Pliers, Cutters, Wire strippers, Screw drivers, Tweezers etc.                                                                                                                                                                               |
| 4 | Testing of electronic components [Resistor, Capacitor, Diode, Transistor and JFET using multimeter.                                                                                                                                                                                                                                                                                                                 |
| 5 | Inter-connection methods using Bread board and soldering practice. [Soldering - types - selection of materials and safety precautions, soldering practice in connectors and general purpose PCB]                                                                                                                                                                                                                    |
| 6 | Design and fabrication of a single sided PCB for a simple circuit with manual etching (Ferric chloride) and drilling.                                                                                                                                                                                                                                                                                               |
| 7 | Assembling of electronic circuit/system on general purpose PCB or breadboard, test and show the functioning (Any Two circuits).<br><br>1. Fixed voltage power supply with transformer, rectifier diode, capacitor filter, Zener/IC regulator.<br><br>2. Astable Multivibrator using Transistor<br><br>3. Sine wave generation using IC 741 OP-AMP in IC base.<br><br>4. RC coupled amplifier with transistor BC107. |

### Reference Books

1. "Electronic Devices and Circuit Theory" by Robert L. Boylestad and Louis Nashelsky.
2. "Fundamentals of Electric Circuits" by Charles K. Alexander and Matthew N.O. Sadiku .
3. "The Soldering Handbook" by M.W. Schwartz.
4. "Electronic Devices Conventional current version", by Floyd 9<sup>th</sup> Edition.

| B24ES1L01A | PROGRAMMING<br>LAB(A) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|------------|-----------------------|---|---|---|---|--------|-------------------------|
|            |                       | 0 | 0 | 3 | 2 | 2      | 2024                    |

### Preamble

The course aims to provide students with exposure to problem solving through C Programming. The students will have hands on experience in C programming, array handling, string manipulations, function creation, structure and pointer operations and file processing. After the lab sessions the student will be able to analyze complex problems and find solutions for real word problems.

### Prerequisite

Nil

### Course Outcomes

After the completion of the course the student will be able to

|      |                                                                                                                                                                                                                          |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | C programs with branching and looping statements for processing arrays and matrices. (Cognitive Knowledge Level: Apply)                                                                                                  |
| CO 2 | Divide a given computational problem into a number of modules and develop functions to find the solutions to the computational problem and also create programs for string processing (Cognitive Knowledge Level: Apply) |
| CO 3 | Construct C programs for searching and sorting (Cognitive Knowledge Level: Apply)                                                                                                                                        |
| CO 4 | Develop C programs which use structures and pointers for data processing and parameter passing (Cognitive Knowledge Level: Apply)                                                                                        |
| CO 5 | Develop C programs for file processing (Cognitive Knowledge Level: Apply)                                                                                                                                                |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 2    | 2    | 1    | 2    | 2    | 0    | 0    | 0    | 1    | 0     | 0     |
| CO 2 | 2    | 3    | 3    | 2    | 3    | 1    | 0    | 0    | 2    | 1     | 3     |
| CO 3 | 2    | 3    | 2    | 2    | 3    | 0    | 0    | 0    | 1    | 0     | 0     |
| CO 4 | 2    | 3    | 3    | 2    | 3    | 1    | 0    | 0    | 2    | 0     | 1     |
| CO 5 | 2    | 3    | 2    | 2    | 3    | 0    | 0    | 0    | 3    | 0     | 1     |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                  |          |
|----------------------------------|----------|
| Attendance                       | 10 marks |
| Class Work/ Assessment Viva-Voce | 20 marks |
| Viva-Voce/ Test                  | 20 marks |

### End Semester Examination (ESE) Pattern:

The following guidelines should be followed regarding the award of marks

|           |          |
|-----------|----------|
| Algorithm | 20 marks |
| Program   | 30 marks |
| Viva-Voce | 30 marks |
| Output    | 20 marks |

## SYLLABUS

### LIST OF EXPERIMENTS

|   |                                                                                                                                                                                                                                                                              |
|---|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Familiarization of Linux Commands.                                                                                                                                                                                                                                           |
| 2 | Familiarization of IO console.<br><br>a) Write a C program to display the Personal details.<br><br>b) Write a C program to Add two numbers<br><br>c) Write a C program to evaluate the arithmetic expression using command line arguments                                    |
| 3 | Familiarization of Operators.<br><br>a) Write a C program to evaluate bitwise operations on given numbers.<br><br>b) Write a C program to swap two numbers using XOR operation.<br><br>c) Write a C program to find the largest of three numbers using conditional operator. |
| 4 | Write a C program for the salary increment of an employee (eg: if the given salary is > 50000, 20 % increment)                                                                                                                                                               |
| 5 | Write a menu driven program to perform the Calculator operations, namely addition, subtraction, multiplication, division and square of a number.                                                                                                                             |



|    |                                                                                                                                                                                                                                                                                         |
|----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6  | Write a C program to check the given number is Armstrong or not and find the reverse of the number                                                                                                                                                                                      |
| 7  | Write a C program to find the sum of first N natural numbers using array.                                                                                                                                                                                                               |
| 8  | Write a C program<br>a) To read an array of size n and display in reverse order.<br>b) Display the sum and average of the array elements.                                                                                                                                               |
| 9  | Write a C program to read an array of size n and display the prime numbers in the array.                                                                                                                                                                                                |
| 10 | Write a C program to read n integers, store them in an array and search for an element in the array using Linear Search.                                                                                                                                                                |
| 11 | Write a C program to read n integers, store them in an array and sort the elements using Bubble Sort.                                                                                                                                                                                   |
| 12 | Write a C program to read a string (word), store it in an array and check whether it is a palindrome word or not.                                                                                                                                                                       |
| 13 | Write a C program to read two strings (each one ending with a \$ symbol), store them in arrays and concatenate them without using library functions.                                                                                                                                    |
| 14 | Write a C program to read a string (ending with a \$ symbol), store it in an array and count the number of vowels, consonants and spaces in it.                                                                                                                                         |
| 15 | Write a C program to read a string (word), store it in an array and obtain its reverse by using a user defined function.                                                                                                                                                                |
| 16 | Write a menu driven program for performing matrix addition, multiplication and finding the transpose. Use functions to<br>a) Read a matrix.<br>b) Find the sum of two matrices.<br>c) Find the product of two matrices<br>d) Find the transpose of a matrix and<br>e) Display a matrix. |
| 17 | Find the factorial of a given Natural Number n using recursive and non-recursive functions.                                                                                                                                                                                             |
| 18 | Write a C Program to find the largest of three numbers using Macros.                                                                                                                                                                                                                    |
| 19 | Using structure, read and print data of n employees (Name, Employee Id and Salary).                                                                                                                                                                                                     |
| 20 | Write a C program to declare a union containing 5 string variables (Name, House Name, City Name, State and Pin code) each with a length of C_SIZE (user defined constant).Then, read and display the address of a person using a variable of the union.                                 |
| 21 | Write a C program to read the student details using structure and display the information through the user defined function.                                                                                                                                                            |
| 22 | Do the following using pointers<br>a) add two numbers.<br>b) swap two numbers using a user defined function.                                                                                                                                                                            |

|           |                                                                                                                                                                                                |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>23</b> | Read and display the elements of an array using pointers, Compute the sum of the elements stored in the array using pointers and user defined function.                                        |
| <b>24</b> | Create a file and perform the following<br>a) Write data to the file.<br>b) Read the data in a given file & display the file content on console .<br>c) append new data and display on console |
| <b>25</b> | Open a text file and count the number of characters, words and lines in it; and store the result in another file.                                                                              |
| <b>26</b> | Find the substring from the given text file and replace it with another string.                                                                                                                |

### **Reference Books**

1. Programming in C - Stephen C. Kochan, CBS publishers.
2. Programming in C – E. Balaguruswamy , Mc Graw Hill.
3. Let us C – Yashwant Kanetkar, BPB.
4. A Book on C – Al Kelley and Ira Pohl, Addison-Wesley.
5. Mastering Turbo C - Stan Kelly Bootle, BPB Publications.
6. Pointers in C - Yashwant Kanetkar, BPB.
7. SThe Spirit of C- by Munish cooper, Jaico Books.

| <b>B24PC1L01A</b> | <b>PHYSICS(A)<br/>AND<br/>CHEMISTRY(A)<br/>LAB</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF<br/>INTRODUCTION</b> |
|-------------------|----------------------------------------------------|----------|----------|----------|----------|---------------|---------------------------------|
|                   |                                                    | 0        | 0        | 2        | 2        | 1             | 2024                            |

**Preamble**

This integrated Physics-Chemistry laboratory course is designed to provide engineering students with essential hands-on experience and foundational experimental skills. Through a series of structured experiments, students will develop proficiency in precise measurement and accurate data recording. The course bridges the gap between theoretical concepts and practical applications by enabling learners to operate scientific instruments, perform fundamental chemical techniques and critically compare experimental results with theoretical predictions. This experiential learning course equips students to critically analyse and interpret data effectively and apply the physical and chemical principles to address complex engineering challenges.

**Prerequisite**

Nil

**Course Outcomes**

After the completion of the course the student will be able to

|             |                                                                                                                                                                                 |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Develop analytical/experimental skills and impart prerequisite hands-on experience for engineering laboratories. (Cognitive Knowledge Level: Apply)                             |
| <b>CO 2</b> | Understand the need for precise measurement practices for data recording. (Cognitive Knowledge Level: Apply)                                                                    |
| <b>CO 3</b> | Understand the principle, concept, working and applications of relevant technologies and compare results with theoretical calculations. (Cognitive Knowledge Level: Apply)      |
| <b>CO 4</b> | Understand and practice fundamental techniques in chemistry to generate experimental skills. (Cognitive Knowledge Level: Apply)                                                 |
| <b>CO 5</b> | Learn to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments. (Cognitive Knowledge Level: Apply)               |
| <b>CO 6</b> | Acquire the ability to understand different methods of chemical synthesis and instrumental techniques to solve various engineering problems. (Cognitive Knowledge Level: Apply) |

## Mapping of Course Outcomes With Program Outcomes

|      | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| CO 1 | 2   |     |     | 1   | 1   |     |     |     |     |      |      |
| CO 2 | 1   |     |     | 1   | 1   |     |     |     |     |      |      |
| CO 3 | 2   | 1   |     |     |     |     |     |     |     |      |      |
| CO 4 | 1   | 1   |     | 1   | 1   |     |     |     |     |      |      |
| CO 5 | 1   | 1   |     | 3   | 1   |     |     |     |     |      |      |
| CO 6 | 2   | 1   |     | 1   |     |     |     |     |     |      |      |

## Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 70        | 30        | 1 Hour       |

## Continuous Internal Evaluation Pattern

|                                                      |          |
|------------------------------------------------------|----------|
| Attendance                                           | 20 marks |
| Class Work/ Assessment Viva voce                     | 50 marks |
| End semester examination (Internally by the college) | 30 marks |

## End Semester Examination Pattern

The college will internally conduct the end semester examination. Separate ESE's will be held for Physics Lab and Chemistry Lab, each in the form of a 30 minutes written objective examination. The total marks for this course will be equally divided between Physics Lab and Chemistry Lab.

## SYLLABUS

### LIST OF EXPERIMENTS PART I PHYSICS LAB(A)

|   |                                                            |
|---|------------------------------------------------------------|
| 1 | WDSO-Measurement of frequency and amplitude of wave forms. |
| 2 | Optic Fiber -Measurement of Splice Loss.                   |
| 3 | Junction Diode - Measurement of $E_R$ .                    |
| 4 | Photoelectric cell - Calculation of Planck's constant.     |
| 5 | Optic Fiber - Measurement of Numerical Aperture.           |
| 6 | I-V characteristics of solar cells.                        |
| 7 | Optic Fiber - Measurement of Bending Loss.                 |
| 8 | LED Characteristics.                                       |

**PART II**  
**CHEMISTRY LAB (A)**

**(MINIMUM FOUR EXPERIMENTS ARE MANDATORY)**

|   |                                                                                                                  |
|---|------------------------------------------------------------------------------------------------------------------|
| 1 | Determination of molar absorptivity of a compound.                                                               |
| 2 | Potentiometric redox titration.                                                                                  |
| 3 | Verification of Nernst equation using Daniel cell.                                                               |
| 4 | Determination of wavelength of absorption maximum and colorimetric estimation of $Fe^{3+}$ ions in the solution. |
| 5 | Electroplating with copper.                                                                                      |
| 6 | Synthesis of iron oxide nanoparticles.                                                                           |
| 7 | Estimation of sodium ions by flame photometry.                                                                   |
| 8 | Synthesis of conducting polyaniline from aniline.                                                                |

**Reference Books**

1. S.L. Gupta and Dr. V. Kumar, "Practical Physics with viva voice", Pragati Prakashan Publishers, Revised Edition, 2009.
2. M.N. Avadhanulu, A.A. Dani and Pokely P.M, "Experiments in Engineering Physics", S.Chand & Co, 2008.
3. S. K. Gupta, "Engineering physics practicals", Krishna Prakashan Pvt. Ltd., 2014 .
4. P. R. Sasikumar, "Practical Physics", PHI Ltd., 2011.
5. D.R Mehta, "Laboratory Manual Physics", D.K Publishing House.
6. G. Svehla, B. Sivasankar, "Vogel's Qualitative Inorganic Analysis", Pearson, 2012.
7. R. K. Mohapatra, "Engineering Chemistry with Laboratory Experiments", PHI Learning, 2017.
8. Muhammed Arif, "Engineering Chemistry Lab Manual", Owl publishers, 2019.
9. Roy K. Varghese, "Engineering Chemistry Laboratory Manual", Crown plus Publishers, 2019.
10. Soney C. George, Rino Laly Jose, "Lab Manual of Engineering Chemistry", S. Chand & Company Pvt Ltd., New Delhi, 2019.
11. S. M. Ashraf, "A Laboratory Manual of Polymers" I. K. International Publishing House Pvt. Ltd., 2008
12. Ulrich Schubert, Nicola Hüsing, "Material Synthesis: A Practical Guide", Springer Vienna, 2008.
13. Anu Tresa Sunny, Prajitha Velayudhan, Sabu Thomas, "Colloidal metal Oxide Nanoparticles: Synthesis, Characterization and Applications", Elsevier Science, 2019.



| B24MC1T01 | LIFE SKILLS | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|-------------|---|---|---|---|--------|----------------------|
|           |             | 1 | 0 | 1 | 2 | P/F    | 2024                 |

### Preamble

This Course is aimed at equipping individuals with the essential competencies to navigate life's challenges with resilience and positivity. This course, embarks on a profound exploration of personal development, fostering self-awareness, meaningful connections, and the ability to navigate the complexities of both the abstract and the concrete aspects of life. It aims to enhance employability by providing practical insights and hands-on experiences that will empower one to apply these principles effectively in one's personal and professional endeavors.

### Prerequisites

Nil

### Course Outcomes

After the completion of the course the student will be able to:

|      |                                                                                                                                                                                         |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Empower individuals with the knowledge and practical skills needed to navigate life challenges and to cope with emotions and stress. (Cognitive Knowledge Level: Apply)                 |
| CO 2 | Develop a profound understanding of themselves and others, leading a fulfilling professional life by embracing a holistic approach to well being. (Cognitive Knowledge Level: Analyzes) |
| CO 3 | Provide a solid foundation in leadership principles and team dynamics. (Cognitive Knowledge Level: Apply)                                                                               |
| CO 4 | Basic understanding of financial concepts for financial well being. (Cognitive Knowledge Level: Apply)                                                                                  |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 1    | 1    |      |      |      | 2    | 2    | 3    | 2    | 2     | 2     |
| CO 2 | 1    | 1    |      |      |      | 2    | 3    | 3    | 2    | 2     | 2     |
| CO 3 | 1    | 1    |      |      |      | 2    | 2    | 3    |      | 3     | 2     |
| CO 4 | 2    | 1    | 2    |      |      | 2    |      |      |      | 3     |       |

### Assessment Pattern



| Bloom's Category | Continuous Assessment | End Semester Examination (% Marks) |
|------------------|-----------------------|------------------------------------|
|                  | Test (%Marks)         |                                    |
| Remember         | 20                    | 20                                 |
| Understand       | 20                    | 20                                 |
| Apply            | 30                    | 30                                 |
| Analyse          | 30                    | 30                                 |
| Evaluate         |                       |                                    |
| Create           |                       |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 50        | 50        | 2 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (1 numbers) | 25 marks |
| Self Study (Regular assessment)        | 15 marks |

### Regular assessment

#### Group Discussion (Marks: 9)

Create groups of about 6 students each and engage them on a GD on a suitable topic for about 20 minutes. Parameters to be used for evaluation are as follows:

1. Communication Skills: 3 marks
2. Subject Clarity: 2 marks
3. Group Dynamics: 2 marks
4. Behaviors & Mannerisms: 2 marks

#### Presentation Skills (Marks: 6)

Identify a suitable topic and ask the students to prepare presentation (preferably a powerpoint presentation) for about 10 minutes. Parameters to be used for evaluation are as follows

1. Communication Skills: 2 marks

2. Platform Skills: 2 marks
3. Subject Clarity/Knowledge: 2 marks

### **End Semester Examination Pattern**

#### **Part A: Short answer question (20 marks)**

There will be one question from each MODULE (four questions in total, five marks each). Each question should be written in about maximum of 400 words. Parameters to be used for evaluation are as follows:

1. Content Clarity/Subject Knowledge
2. Presentation style
3. Organization of content

#### **Part B: Case Study (30 marks)**

The students will be given a case study with questions at the end. The students have to analyze the case and answer the question at the end. Parameters to be used for evaluation are as follows:

1. Analyze the case situation
2. Key players/characters of the case
3. Identification of the problem (both major & minor if exists)
4. Bring out alternatives
5. Analyze each alternative against the problem
6. Choose the best alternative
7. Implement as solution
8. Conclusion
9. Answer the question at the end of the case

## **SYLLABUS**

### **MODULE 1 (6 hours)**

#### **Overview of Life Skills:**

Meaning and significance of life skills, Life skills identified by WHO: Self-awareness, Empathy, Critical thinking, Creative thinking, Decision making, problem solving, Effective communication, interpersonal relationship, coping with stress- Four A's of stress management, Gratitude Training, Coping with emotion- PATH method and relaxation techniques.

### **MODULE 2 (6 hours)**

#### **Life Skills for Professionals:**

positive thinking, right attitude, Experience, attention to detail, having the big picture, learning skills, research skills, setting goals and achieving them, perseverance, motivation, self-motivation, and motivating others, IQ, EQ, and SQ, Collaboration, continuous learning, unlearning and relearning, cross cultural communication, social media etiquettes, Financial Literacy.

Time Management: Prioritizing tasks, setting realistic goals and managing time effectively, work life balance.

Holistic Thinking: imagination, intuition, lateral thinking, Multiple intelligence, spirituality, family bonding, living peacefully.

### **MODULE 3 (6 hours)**

#### **Leadership:**

Leadership traits, Styles of Leadership, VUCA Leadership, Transactional vs Transformational Leaders, managing diverse stakeholders, crisis management, Effective Leaders.

**Group and Team Dynamics:** Group vs Team, Team Dynamics, Virtual teams, managing team performance and managing conflicts, Intrapreneurship

### **MODULE 4 (6 hours)**

#### **Financial Literacy:**

Time value of money, power of compounding, Future value of a single cash flow, effective versus nominal rate, Future value of an annuity, present value of a single cash flow, Present value of an annuity.

#### **Reference Books**

1. Shiv Khera, You Can Win, Macmillan Books, New York, 2003.

2. Barun K. Mitra, "Personality Development & Soft Skills", Oxford Publishers, Third impression, 2017.
3. ICT Academy of Kerala, "Life Skills for Engineers", McGraw Hill Education (India) Private Ltd., 2016.
4. Caruso, D. R. and Salovey P, "The Emotionally Intelligent Manager: How to Develop and Use the Four Key Emotional Skills of Leadership", John Wiley & Sons, 2004.
5. Kalyana, "Soft Skill for Managers"; First Edition; Wiley Publishing Ltd, 2015.
6. Larry James, "The First Book of Life Skills"; First Edition, Embassy Books, 2016.
7. Shalini Verma, "Development of Life Skills and Professional Practice"; First Edition; Sultan Chand (G/L) & Company, 2014.
8. Daniel Goleman, "Emotional Intelligence"; Bantam, 2006.
9. Remesh S., Vishnu R.G., "Life Skills for Engineers", Ridhima Publications, First Edition, 2016.
10. Butterfield Jeff, "Soft Skills for Everyone", Cengage Learning India Pvt Ltd; 1 edition, 2011.
11. Training in Interpersonal Skills: Tips for Managing People at Work, Pearson Education, India; 6 editions, 2015.
12. The Ace of Soft Skills: Attitude, Communication and Etiquette for Success, Pearson Education; 1 edition, 2013
13. Prasanna Chandra, "Fundamentals of Financial Management", McGraw Hill Education (India) Private Ltd, 2020
14. Edward de Bono, "Lateral Thinking"
15. Howard Gardener, "Multiple Intelligences"

### **COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                                                                                                                                           | No of Lecture/Tutorial Hours |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | Total Hours                                                                                                                                                                     | 24 Hours                     |
|     | <b>Module 1</b>                                                                                                                                                                 | 6                            |
| 1.1 | Overview of Life Skills: Meaning and significance of life skills, Life skills identified by WHO: Self-awareness, Empathy, Critical thinking, Creative thinking, Decision making | 1                            |

|     |                                                                                                                                                                                                                                                                  |   |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 1.2 | Problem solving, Effective communication, interpersonal relationship, coping with stress- Four A's of stress management.                                                                                                                                         | 1 |
| 1.3 | Gratitude Training, Coping with emotion- PATH method and relaxation techniques                                                                                                                                                                                   | 1 |
| 1.4 | Activity- Presentation, Group discussion                                                                                                                                                                                                                         | 3 |
|     | <b>Module 2</b>                                                                                                                                                                                                                                                  | 6 |
| 2.1 | Life skills for professionals: positive thinking, right attitude, Experience, attention to detail, having the big picture, learning skills, research skills, setting goals and achieving them, perseverance, motivation, self-motivation, and motivating others, | 1 |
| 2.2 | IQ, EQ, and SQ, Collaboration, continuous learning, unlearning and relearning, cross cultural communication, social media etiquettes, Financial Literacy.                                                                                                        | 1 |
| 2.3 | Time management: Prioritizing tasks, setting realistic goals and managing time effectively, work life balance.                                                                                                                                                   | 1 |
| 2.4 | Holistic Thinking: imagination, intuition, lateral thinking, Multiple intelligence, spirituality, family bonding, living peacefully.                                                                                                                             | 1 |
| 2.5 | Activity- Presentation, Group discussion.                                                                                                                                                                                                                        | 2 |
|     | <b>Module 3:</b>                                                                                                                                                                                                                                                 | 6 |
| 3.1 | Leadership: Leadership traits, Styles of Leadership, VUCA Leadership, Transactional vs Transformational Leaders, managing diverse stakeholders, crisis management, Effective Leaders.                                                                            | 1 |
| 3.2 | Group and Team Dynamics: Group vs Team, Team Dynamics, Virtual teams, managing team performance and managing conflicts, Intrapreneurship                                                                                                                         | 1 |
| 3.3 | Activity- Presentation, Group discussion                                                                                                                                                                                                                         | 4 |
|     | <b>Module 4:</b>                                                                                                                                                                                                                                                 | 6 |
| 4.1 | Financial Literacy: Time value of money, power of compounding, Future value of a single cash flow.                                                                                                                                                               | 1 |
| 4.2 | Effective versus nominal rate, Future value of an annuity.                                                                                                                                                                                                       | 1 |
| 4.3 | Present value of a single cash flow, Present value of an annuity.                                                                                                                                                                                                | 1 |
| 4.4 | Activity- Presentation, Group discussion                                                                                                                                                                                                                         | 3 |

## CO ASSESSMENT QUESTIONS

### Course Outcome 1 (CO 1):

1. What are the life skills identified by WHO?

2. List the 4 A's of stress management.
3. Differentiate between Critical thinking and Creative thinking.

**Course Outcome 2 (CO 2):**

1. What are the life skills that a professional should have?
2. Explain how time management can help in work life balance.
3. What is the difference between intuition and lateral thinking?

**Course Outcome 3 (CO 3):**

1. How a person can grow as a leader in an organization?
2. Discuss the term "Crisis management".
3. What are the differences between a team and a group?

**Course Outcome 4 (CO 4):**

1. A finance company advertises that it will pay a lumpsum of Rs. 10000 at the end of 6 years to investors who deposit annually Rs. 1000. What interest rate is implicit in this offer?
2. How much should be deposited at the beginning of each year for 10 years in order to provide a sum of Rs. 50000 at the end of 10 years?
3. Suppose you deposit Rs. 10000 with an investment company which pays 8 percent interest with quarterly compounding. How much will this deposit grow in 5 years?



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 2**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FIRST SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2024**

**Course Code: B24MC1T01**

**Course Name: LIFE SKILLS**

**Max. Marks: 50**

**Duration: 2 hours**

**PART A**

**Answer all questions. Each question carries 5 marks.**

1. Stress is the emotional or physical tension the body creates when presented with events or thoughts that cause worry, frustration, anger or nervousness. When stress exceeds the ability to cope, balance in the mind and body need to be restored. Discuss how stress management can act as an effective tool to accomplish this.
2. "The only limit to our realization of tomorrow is our doubts of today." – Franklin D. Roosevelt. Critically assess how cultivating positive thinking and maintaining a right attitude can transform professional challenges into opportunities for growth.
3. Discuss leadership styles that are effective for successful management of multicultural groups and teams.
4. Mr. Vinay plans to send his son for higher studies abroad after 10 years. He expects the cost of these studies to be Rs. 100000. How much should he save annually to have a sum of Rs. 100000 at the end of 10 years if the interest rate is 12 percent?

**PART B**

**Read carefully the following case and answer the questions given below.**

**Each question carries 6 marks.**

1. Based on the case study given below, answer the following questions: It occurred on the night of 2–3 December 1984 at the Union Carbide India Limited (UCIL) pesticide plant in Bhopal, Madhya Pradesh. Over 500,000 people were exposed to Methyl Isocyanate (MIC) gas and other chemicals. A runaway reaction had occurred in a storage tank of Methyl Isocyanate (MIC), which was used to manufacture a pesticide. The valves of the tank had burst, and a cloud of poisonous gas had escaped. The winds carried it to nearby shanty towns and the populous city of Bhopal, where thousands of people either died in their sleep or woke and died while fleeing. Those who survived suffered from burning eyes and lungs. Local medical facilities were not equipped for the disaster, and over the next few weeks' thousands more died. The killer gas spread through the city, sending residents scurrying through the dark streets. No alarm ever sounded a warning, so that local people were not informed the situation, and no evacuation plan was prepared. When victims arrived at hospitals breathless and blind, doctors did not know how to treat them, as UCIL had not provided emergency information. Perhaps most importantly at the time of the tragedy, the staff did not realize the gravity of the situation and even took a break for tea after the leak had been noticed, thinking they would have plenty of time to fix it. The operator in the control room did not notify his supervisor when the temperature began to rise inside the tank and the entire situation remained unattended for at least an hour. The disaster raised some serious ethical issues. The pesticide factory was built in the midst of densely populated settlements. UCIL chose to store and produce MIC, one of the deadliest chemicals (permitted exposure levels in USA and Britain are 0.02 parts per million), in an area where nearly 120,000 people lived. The MIC plant was not designed to handle a runaway reaction. When the uncontrolled reaction started, MIC was flowing through the scrubber (meant to neutralize MIC emissions) at more than 200 times its designed capacity.

- (a) Critique the communication strategy (or lack thereof) employed by UCIL during the disaster. How did the absence of timely warnings and information affect the outcome?
- (b) Assess the ethical implications of UCIL's decision to build a pesticide plant in a densely populated area. How should corporate responsibility have been exercised in this context?
- (c) As an engineer, comment on the drawback of the design which may have the reason for the tragedy.
- (d) Evaluate the leadership displayed by UCIL's management during the Bhopal disaster. How did their response, or lack thereof, impact the outcome of the crisis?
- (e) Reflect on the lessons learned from the Bhopal disaster. What key takeaways should industries and governments derive from this incident to enhance safety and prevent future catastrophes?

| B24MC1T02 | DESIGN THINKING | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|-----------------|---|---|---|---|--------|----------------------|
|           |                 | 1 | 1 | 0 | 2 |        |                      |

### Preamble

This course gives students a comprehensive understanding of the iterative design process and its real-world applications. It covers the fundamentals of design thinking, including concept development, brainstorming, and creativity enhancement. Emphasizing customer needs identification and human-centered design principles, it explores product conceptualization and evaluation, along with prototyping techniques. Additionally, the course addresses ethical considerations and challenges within the design thinking process through diverse case studies. By the end of the course, students will gain practical insights into design thinking methodologies, preparing them to effectively tackle complex design challenges.

### Prerequisites

Nil

### Course Outcomes

After the completion of the course the student will be able to:

|             |                                                                                                                                                                |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Exhibit/show a thorough understanding of the fundamental principles of the design thinking methodology. (Cognitive Knowledge Level: Understand )               |
| <b>CO 2</b> | Utilize diverse techniques effectively to generate creative concepts, adopting innovation and ideation. (Cognitive Knowledge Level: Apply)                     |
| <b>CO 3</b> | Demonstrate expertise in ideating prototypes, models, and proof-of-concept iterations. (Cognitive Knowledge Level: Analyse)                                    |
| <b>CO 4</b> | Analyze real-world challenges and develop a practical design thinking framework suitable for their professional endeavors. (Cognitive Knowledge Level: Create) |

### Mapping of Course Outcomes With Program Outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 2    | 1    | 3    | 1    | 1    | 1    | 1    | 2    | 1    | 1     | 1     |
| <b>CO 2</b> | 2    | 2    | 3    | 1    | 1    | 1    | 1    | 2    | 1    | 1     | 1     |
| <b>CO 3</b> | 2    | 2    | 3    | 1    | 1    | 1    | 1    | 2    | 1    | 1     | 1     |
| <b>CO 4</b> | 2    | 2    | 3    | 1    | 1    | 1    | 1    | 2    | 1    | 1     | 1     |

### Assessment Pattern Assessment Pattern

| Bloom's Category | Continuous Assessment |                                                   | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|---------------------------------------------------|---------------------------------------|
|                  | Test<br>(%Marks)      | Case Study<br>Presentation<br>(Marks)<br>(%Marks) |                                       |
| Remember         | 25                    |                                                   | 20                                    |
| Understand       | 25                    |                                                   | 20                                    |
| Apply            | 25                    |                                                   | 20                                    |
| Analyse          | 25                    |                                                   | 20                                    |
| Evaluate         |                       |                                                   |                                       |
| Create           |                       | 100                                               | 20                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 50        | 50        | 2 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (1 numbers) | 25 marks |
| Self Study (Case Study Presentation)   | 15 marks |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. Part A contain 4 questions carrying 5 marks each. Part B contains 2 questions from each module out of which 1 to be answered and can have maximum 2 sub- divisions. Questions from Module 1&2 carries 8 marks each and Module 3&4 carries 7 marks.

## SYLLABUS

### MODULE 1 (5 hours)

#### Design Thinking Approach:

Introduction to Design Thinking; Iterative Design Thinking Process Stages: Empathize, Define, Ideate, Prototype and Test; The double-diamond Model of design by British Design Council.

#### Developing concepts:

Steps to develop concepts from functions; Brainstorming: Mechanism of brainstorming, Ideation; Creativity: How to increase level of creativity.

## **MODULE 2 (6 hours)**

**Design Process:** Requirements: Identifying customer needs and requirements, market analysis, defining goals; Product concepts: establishing functions, task specifications.

**Solution Concept:** conceptualization, evaluating alternatives; embodiment design; Analysis and optimization; experiment; marketing. Human-centred design process.

## **MODULE 3 (6 hours)**

**Concepts Evaluation::** Evaluating conceptual alternatives: Pugh's Evaluation matrix, decision matrix with examples, QFD and house of quality.

**Prototyping:** Prototypes, Models and Proofs of concepts; What is Prototype? Why Prototype? Building models and prototypes, Rapid Prototyping; Lean startup method for prototype development; Testing prototypes and models and proving concepts.

## **MODULE 4 (7 hours)**

**Ethics in Design:** Understanding obligations, code of ethics, familiarity with several code of ethics such as ASCE, ASME, IEEE, VDI etc. code of ethics and moral frameworks.

**Challenges in Design Thinking:** Design thinking case studies detailing the various aspects detailed above are to be discussed. The case studies are suggested to be from the below listed areas but not to be limited to: Consumer package goods; Education; Financial Services; Health care; Journalism; Non-Profit organizations; Retail; Technology; Transportation sector; Self-improvement.

## **Text Books**

1. Yousef Haik & Tamer M Shahin, "Engineering design process", Course Technology, 2010.
2. Clive L Dym, Patrick Little & Elizabeth J Orwin, "Engineering Design-A Project based Introduction", Wiley, 2014.
3. Don Norman, "The Design of Everyday Things", Basic Books; 2nd edition, 2013.
4. Christian Mueller-Roterberg, "Handbook of Design Thinking: Tips and Tools for how to design thinking", 2018.

## **Reference Books**

1. Daniel Kahneman, "Thinking Fast and Slow", Farrar, Straus & Giroux, 2011.
2. Rod Judkins, "The art of Creative Thinking", Penguin Publishing Group, 2016.



3. Donella H Meadows, "Thinking in Systems", Chelsea Green Publishing, 2008.
4. Tim Brown, "Change by Design", HarperCollins, 2019.
5. V.N.Mittle & Arvind Mittal, "Basic Electrical Engineering " 2<sup>nd</sup> Edition, McGraw Hill, 2006.

## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                              | No of Lecture/Tutorial Hours |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | Total Hours                                                                                                                                        | 24 Hours                     |
|     | <b>Module 1</b>                                                                                                                                    | 5                            |
| 1.1 | Design Thinking Approach: Introduction to Design Thinking; Iterative Design Thinking Process Stages: Empathize, Define, Ideate, Prototype and Test | 1                            |
| 1.2 | The double-diamond Model of design by British Design Council                                                                                       | 1                            |
| 1.3 | Developing concepts: Steps to develop concepts from functions                                                                                      | 1                            |
| 1.4 | Brainstorming: Mechanism of brainstorming, Ideation                                                                                                | 1                            |
| 1.5 | Creativity: How to increase level of creativity                                                                                                    | 1                            |
|     | <b>Module 2</b>                                                                                                                                    | 6                            |
| 2.1 | Design Process: Requirements: Identifying customer needs and requirements, market analysis, defining goals                                         | 1                            |
| 2.2 | Product concepts: establishing functions, task specifications                                                                                      | 2                            |
| 2.3 | Solution Concept: conceptualization, evaluating alternatives                                                                                       | 1                            |
| 2.4 | Embodiment design; Analysis and optimization; experiment; marketing                                                                                | 1                            |
| 2.6 | Human centred design process                                                                                                                       | 1                            |
|     | <b>Module 3:</b>                                                                                                                                   | 6                            |
| 3.1 | Concepts Evaluation: Evaluating conceptual alternatives: Pugh's Evaluation matrix, decision matrix with examples.                                  | 2                            |
| 3.2 | Prototypes, Models and Proofs of concepts                                                                                                          | 1                            |
| 3.3 | What is Prototype? Why Prototype? Building models and prototypes, Rapid Prototyping                                                                | 1                            |
| 3.4 | Lean startup method for prototype development; Testing prototypes and models and proving concepts                                                  | 2                            |
|     | <b>Module 4:</b>                                                                                                                                   | 7                            |



|     |                                                                                                                                                                       |   |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 4.1 | Ethics in Design: Understanding obligations, code of ethics, familiarity with several code of ethics such as ASCE, IEEE, VDI etc. code of ethics and moral frameworks | 1 |
| 4.2 | Challenges in Design thinking                                                                                                                                         | 1 |
| 4.3 | Design thinking case studies detailing the various aspects                                                                                                            | 5 |

## CO ASSESSMENT QUESTIONS

### Course Outcome 1 (CO 1):

1. Describe design thinking and list the different stages in a design thinking process.
2. Illustrate the double-diamond Model of design.
3. Describe how to develop concepts from functions and Mechanism of brainstorming.
4. How to increase the level of creativity and the process of forming ideas from conception to implementation?

### Course Outcome 2 (CO 2):

1. How to narrow down to the best design considering the customer needs and requirements, market analysis and defining goals?
2. Illustrate the process of product concepts, forming ideas and embodiment design.
3. Explain the Human-centred design process.

### Course Outcome 3 (CO 3):

1. Describe the concept evaluation using Pugh's Evaluation matrix, and decision matrix with examples.
2. Explain the ideation of prototypes, models, and proofs of concepts.
3. Illustrate the concept of Rapid Prototyping, the Lean startup method for prototype development and testing of prototypes.

### Course Outcome 4 (CO 4):

1. Discuss as an engineer, how ethics play a decisive role in design.
2. Analyze the Challenges in Design thinking.
3. Design the functional structure of a shopping cart.
4. Examine the changes that can be made in the design of a bag with constraints of cost, reliability issues, production methods and environmental factors.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

FIRST SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2024

**Course Code: B24MC1T02**

**Course Name: DESIGN THINKING**

Max. Marks: 50

Duration: 2 hours

**PART A**

**Answer all questions. Each question carries 5 marks.**

1. Demonstrate the basic concept of brainstorming and the rules developed for brainstorming session.
2. Briefly explain what is product and solution concepts in design process.
3. Distinguish between prototypes and models.
4. Explain the importance of ethics in design.

**PART B**

**Answer any one question from each module.**

5. What do you mean by design thinking and why it is needed. How does the design thinking approach help engineers. 8

**OR**

6. Summarize different stages of design thinking process using appropriate examples.. 8
7. Illustrate different phases of extensive prescriptive model of design process. 8

**OR**

8. Identify the customer requirements with the help of refrigerator as example, 8
9. How concepts evaluation can be done using Pugh's evaluation matrix. Compare Pugh's evaluation matrix with the decision matrix. 7

**OR**

10. List the different methods in which the prototype of a product can be generated and tested. 7
11. Design a device/machine that will crush aluminum cans. The device must be fully automatic. The device should switch on automatically, crush the can automatically, eject the crushed can automatically and switch off automatically. 7

**OR**

12. Design a new shopping cart that can be used primarily in grocery stores. The shopping cart should solve the common problems in the available carts. There is a tendency to conserve parking space by not designating a return cart area. Leaving cart in the parking lots may lead to serious accidents and car damage. Many customers do not fill their carts when shopping; however, they do not like to carry baskets. Other customers like to sort products as they shop. 7

| B24MC1L01 | YOGA AND SPORTS | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|-----------------|---|---|---|---|--------|----------------------|
|           |                 | 0 | 1 | 1 | 1 | P/F    | 2024                 |

**Preamble**

This course enables the learners to understand how to attain physical fitness, mental well-being, and holistic growth through the combined benefits of yoga and sports. The topics covered in this course are Yoga & Lifestyle Physical fitness, wellness and exercise programmes, First aid and Postures & nutrition. This course helps the students to develop appreciation of physical activity as a lifetime pursuit and a means to better health.

**Prerequisites**

Nil

**Course Outcomes**

After the completion of the course the student will be able to:

|             |                                                                                                                                                           |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Demonstrate the need of physical activities and Yoga for the strength, flexibility, and relaxation of mind and body. ( Cognitive Knowledge Level :Apply ) |
| <b>CO 2</b> | Use scientific principles of exercise and training in daily routine. (Cognitive Knowledge Level :Apply)                                                   |
| <b>CO 3</b> | Apply first aid promptly and appropriately whenever and wherever the need arises.(Cognitive Knowledge Level :Apply )                                      |
| <b>CO 4</b> | Understand the importance of postures and nutrition (Cognitive Knowledge Level :Understand )                                                              |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> |      |      |      |      |      |      | 2    | 3    | 2    |       | 2     |
| <b>CO 2</b> |      |      |      |      |      |      | 3    | 3    | 2    |       | 2     |
| <b>CO 3</b> |      |      |      |      |      | 2    | 3    | 3    | 3    |       | 2     |
| <b>CO 4</b> |      |      |      |      |      |      | 3    | 3    | 2    |       | 2     |

## Mark Distribution

| Total Marks | CIE Marks |
|-------------|-----------|
| 50          | 50        |

## Continuous Internal Evaluation Pattern

|                    |          |
|--------------------|----------|
| Attendance         | 10 marks |
| Regular assessment | 35 marks |
| Self Study         | 5 marks  |

Marks for the regular assessment can be based on the co questions given at the end.

## SYLLABUS

### MODULE 1 (6 hours)

#### Yoga & Lifestyle:

Meaning and importance of Yoga. Introduction-Asanas: Pranayama, Meditation and Yogic Kriyas. Yoga for concentration and related Asanas (Sukhasana; Tadasana; Padmasana and Shashankasana). Relaxation Techniques for improving concentration-Yog-nidra.Asanas as preventive measure.Hypertension: Tadasana, Vajrasana, Pavan Muktasana, Ardha Chakrasana, Bhujangasana, Sharasana.Obesity: Procedure, Benefits and contraindications for Vajrasana, Hastasana, Trikonasana, Ardh Matsyendrasana.Back pain: Tadasana, Ardh Matsyendrasana, Vakrasana, Shalabhasana, Bhujangasana.

### MODULE 2 (6 hours)

#### Physical fitness and exercise:

Meaning and importance of physical fitness and wellness. Components of physical fitness and health related fitness. Exercise for improving speed, strength, endurance, and flexibility and co ordinative abilities.Exercises to prevent back pain, tennis elbow, shoulder injury and knee pain, Neck pain.Fitness test battery for speed, strength, endurance, flexibility.Importance of weight training.Warming up and cooling down.How to deal with every day stress.

### MODULE 3 (6 hours)

#### First aid:

First aid and principles of first aid.First aid measure for the following: Bleeding through Nose, Snakebite, Dog Bite, Electric Shock, Burns and Drowning.Common injuries and their management: Wounds, Cuts, Sprain, Fracture and Dislocation. Cardio Pulmonary Resuscitation (CPR).How to prevent muscle cramps and its management.How to carry an injured person.

## MODULE 4 (6 hours)

### Postures and nutrition:

Posture and its importance. Common Postural Deformities- Knock Knee, Flat Foot, Round Shoulders, Lordosis, Kyphosis, Bow Legs and Scoliosis. Corrective Measures for Postural Deformities. Balanced diet, malnutrition and Deficiency diseases. Hydration

### Text Books

1. Modern Trends and Physical Education by Prof. Ajmer Singh.
2. Light on Yoga by B.K.S. Iyengar.
3. Health and Physical Education- NCERT (11th and 12th Classes)

### Reference Books

4. Physiological aspects of sports training and performance by Jay Hoffman.
5. Periodization theory and methodology of training by Tudor O Bompa and G Grisgery Haff.
6. Essential of strength training and conditioning by Thomas Baechle E R, Roger W Earle.
7. A practice guide to emergency first aid, safety injuries, illnesses by Montreal.

## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                                                                                                                                                 | No of Lecture/Tutorial Hours |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | Total Hours                                                                                                                                                                                                                                                                           | 24 Hours                     |
|     | <b>Module 1</b>                                                                                                                                                                                                                                                                       | 6                            |
| 1.1 | Meaning and importance of Yoga. Introduction-Asanas, Pranayama, Meditation and Yogic Kriyas. Yoga for concentration and related Asanas (Sukhasana; Tadasana; Padmasana and Shashankasana) Relaxation Techniques for improving concentration-Yog-nidra. Asanas as preventive measures. | 2                            |



|     |                                                                                                                                                            |   |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 1.2 | Hypertension: Tadasana, Vajrasana, Pavan Muktasana, Ardha Chakrasana, Bhujangasana, Sharasana.                                                             | 1 |
| 1.3 | Obesity: Procedure, Benefits and contraindications for Vajrasana, Hastasana, Trikonasana, Ardh Matsyendrasana.                                             | 1 |
| 1.4 | Back pain: Tadasana, Ardh Matsyendrasana, Vakrasana, Shalabhasana, Bhujangasana                                                                            | 2 |
|     | <b>Module 2</b>                                                                                                                                            | 6 |
| 2.1 | Meaning and importance of physical fitness and wellness, Components of physical fitness and health related fitness                                         | 1 |
| 2.2 | Exercise for improving speed, strength, endurance, and flexibility and co ordinative abilities                                                             | 1 |
| 2.3 | Exercises to prevent back pain, shoulder injury and knee pain.                                                                                             | 2 |
| 2.4 | Fitness test battery for speed, strength, endurance, flexibility.                                                                                          | 1 |
| 2.5 | Importance of weight training, Warming up and cooling down.                                                                                                | 1 |
|     | <b>Module 3:</b>                                                                                                                                           | 6 |
| 3.1 | First aid and principles of first aid.First aid measure for the following: Bleeding through Nose, Snakebite, Dog Bite, Electric Shock, Burns and Drowning. | 2 |
| 3.2 | Common injuries and their management: Wounds, Cuts, Sprain, Fracture and Dislocation                                                                       | 2 |
| 3.3 | Cardio pulmonary resuscitation (CPR).                                                                                                                      | 1 |
| 3.4 | How to prevent muscle cramps and its management.How to carry an injured person                                                                             | 1 |
|     | <b>Module 4:</b>                                                                                                                                           | 6 |
| 4.1 | Posture and its importance.Common Postural Deformities- Knock Knee, Flat Foot, Round Shoulders.                                                            | 2 |
| 4.2 | Lordosis, Kyphosis, Bow Legs and Scoliosis.Corrective Measures for Postural Deformities.                                                                   | 2 |
| 4.3 | Balanced diet, malnutrition and deficiency disease, Hydration.                                                                                             | 2 |

## CO ASSESSMENT QUESTIONS

### Course Outcome 1 (CO 1):

1. Demonstrate yoga asanas for life style problems
2. Create a PPT presentation on various yoga asanas
3. Group Activity - Group discussion about the need and benefits of physical activities and Yoga for the strength, flexibility, and relaxation of mind and body.

**Course Outcome 2 (CO 2):**

1. Analyze the exercise activities of at least five famous personalities and give a PPT presentation about how each one of them uses physiological principles related to exercise and training in daily routine.
2. Conduct a survey on how the following categories of people follow physiological principles related to exercise and training in daily routine.
  - (a) Sports person
  - (b) Working woman
  - (c) Students
  - (d) Ladies in the age group of 25-35, 35-45, 45- 55, 55-65, above 65
  - (e) Gents in the age group of 25-35, 35-45, 45- 55, 55-65, above 65

**Course Outcome 3 (CO 3):**

1. With a role play, illustrate various first aid activities that can be followed at various situation in life. In each illustration, try to give emphasis on dos and don'ts to be followed in each situation.

**Course Outcome 4 (CO 4):**

1. Observe at least 10 students in your class and identify common postural deformities each one of them have. Also identify good posters they follow. Have a discussion with each one of them to identify whether they have already recognized it or not. Prepare a report on this including your thoughts on the diet they take and its impact on their health.

# **MAR ATHANASIOUS COLLEGE OF ENGINEERING**

Government Aided, Autonomous Institution, Kothamangalam, Kerala,  
India

The logo of Mar Athanasius College of Engineering is a circular emblem with a gear-like outer border. Inside the circle, there is a blue upper half and a green lower half. A brown cross is centered over the blue half, and a green mountain range is depicted at the bottom of the circle. The text "B.Tech" is written in black over the cross, and "Electronics And Communication Engineering" is written in black below it.

**B.Tech**  
**Electronics And Communication  
Engineering**

## **SEMESTER II**

### **SYLLABUS**

**SEMESTER 2**

| SLOT         | COURSE NO. | COURSES                                        | L-T-P-S | HOURS     | CREDIT    |
|--------------|------------|------------------------------------------------|---------|-----------|-----------|
| A            | B24MA1T02  | ORDINARY DIFFERENTIAL EQUATIONS AND TRANSFORMS | 3-1-0-5 | 4         | 4         |
| B            | B24ES1T03A | COMPUTER AIDED ENGINEERING GRAPHICS (A)        | 2-0-2-4 | 4         | 3         |
| C            | B24EC1T02  | ELECTRICAL CIRCUIT THEORY                      | 3-1-0-5 | 4         | 4         |
| D            | B24EC1T03  | LOGIC CIRCUIT DESIGN                           | 2-1-0-4 | 3         | 3         |
| E            | B24EC1T04  | ANALOG CIRCUITS 1                              | 3-1-0-5 | 4         | 4         |
| G            | B24EC1L01  | BASIC ELECTRONICS LAB                          | 0-0-3-2 | 3         | 2         |
| H            | B24EC1L02  | SCIENTIFIC COMPUTING LAB                       | 0-0-3-2 | 3         | 2         |
| I            | B24MC1T03  | PROFESSIONAL COMMUNICATION AND ETHICS          | 2-0-1-4 | 3         | P/F       |
| J            | B24MC1L02  | IDEA LAB                                       | 0-0-2-2 | 2         | P/F       |
| <b>TOTAL</b> |            |                                                |         | <b>30</b> | <b>22</b> |

| B24MA1T02 | ORDINARY<br>DIFFERENTIAL<br>EQUATIONS<br>AND<br>TRANSFORMS | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|------------------------------------------------------------|---|---|---|---|--------|-------------------------|
|           |                                                            | 3 | 1 | 0 | 5 | 4      | 2024                    |

### Preamble:

This course introduces the concepts and applications of differential equations, sequence and series including power series and basic transforms such as Laplace and Fourier transforms. The objective of this course is to familiarize the prospective engineers with some advanced concepts and methods in Mathematics which include differential equations, sequence, series and transforms. The topics treated in this course have applications in all branches of engineering.

**Prerequisites:** Nil

### Course Outcomes:

After the completion of the course the student will be able to:

|      |                                                                                                              |
|------|--------------------------------------------------------------------------------------------------------------|
| CO 1 | Solve homogeneous and non-homogeneous ordinary differential equations using appropriate analytical methods.  |
| CO 2 | Determine the convergence and divergence of sequences and series using standard convergence tests.           |
| CO 3 | Apply Taylor series, Fourier series, and half-range expansions to represent functions.                       |
| CO 4 | Determine the Fourier transforms of functions and apply them to solve problems arising in engineering.       |
| CO 5 | Apply Laplace transforms to model and solve engineering systems governed by ordinary differential equations. |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 1    | 1    |      |      |      |      |      |      |      |       |       |
| CO 2 | 1    | 1    |      |      |      | 1    |      |      |      |       |       |
| CO 3 | 1    | 1    |      |      |      |      |      |      |      |       |       |
| CO 4 | 1    | 1    |      |      | 1    |      |      |      |      |       |       |
| CO 5 | 1    | 1    |      | 1    | 1    | 1    | 1    |      |      |       | 1     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                     | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|---------------------|---------------------------------------|
|                  | Test 1<br>(% Marks)   | Test 2<br>(% Marks) |                                       |
| Remember         | 20                    | 20                  | 20                                    |
| Understand       | 40                    | 40                  | 40                                    |
| Apply            | 40                    | 40                  | 40                                    |
| Analyse          |                       |                     |                                       |
| Evaluate         |                       |                     |                                       |
| Create           |                       |                     |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Quiz/Course Project         | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions carrying 3 marks each. Part B contains 2 questions from each module out of which 1 to be answered. Each question carries 14 marks and can have maximum 2 sub divisions.

## SYLLABUS

### MODULE 1 (Ordinary Differential Equations)

(Text 2: Relevant topics from sections 2.1, 2.2, 2.5, 2.6, 2.7, 2.10, 3.1, 3.2, 3.3)

Homogenous linear differential equation of second order, superposition principle, general solution, homogenous linear ODEs with constant coefficients-general solution. Solution of



Euler-Cauchy equations (second order only). Existence and uniqueness (without proof). Non homogenous linear ODEs-general solution, solution by the method of undetermined coefficients( for the right hand side of the form  $x^n, e^{kx}, \sin ax, \cos ax$  and their linear combinations) , methods of variation of parameters. Solution of higher order equations-homogeneous and non-homogeneous with constant coefficients using method of undetermined coefficients.

## **MODULE 2 (Sequences and Series)**

**(Text 1: Relevant topics from sections 9.1, 9.3, 9.4, 9.5, 9.6)**

Convergence of sequences and series, convergence of geometric series and p-series (without proof), tests of convergence (comparison, limit comparison, ratio and root tests without proof); Alternating series and Leibnitz test, absolute and conditional convergence.

## **MODULE 3 (Fourier Series)**

**(Text 1: Relevant topics from sections 9.8, 9.9. Text 2: Relevant topics from sections 11.1, 11.2, 11.6)**

Taylor series (without proof, assuming the possibility of power series expansion in appropriate domains), Binomial series and series representation of exponential, trigonometric, logarithmic functions (without proofs of convergence); Fourier series, Euler formula, Convergence of Fourier series (without proof), half range sine and cosine series.

## **MODULE 4 (Fourier Transforms)**

**(Text 2: Relevant topics from sections 11.7, 11.8, 11.9)**

Fourier integral representation, Fourier sine and cosine integrals. Fourier sine and cosine transforms, inverse sine and cosine transform. Fourier transform and inverse Fourier transform, basic properties. The Fourier transform of derivatives. Convolution theorem (without proof).

## **MODULE 5 (Laplace Transforms)**

**(Text 2: Relevant topics from sections 6.1, 6.2 ,6.3, 6.4, 6.5)**

Laplace Transform and its inverse, Existence theorem (without proof), linearity, Laplace transform of basic functions, first shifting theorem, Laplace transform of derivatives and integrals, solution of differential equations using Laplace transform, Unit step function, Second shifting theorem. Dirac delta function and its Laplace transform, Solution of ordinary differential equation involving unit step function and Dirac delta functions. Convolution theorem (without proof) and its application to finding inverse Laplace transform of products of functions.

### **Text Books**

1. H. Anton, I. Biven, S. Davis, “Calculus”, Wiley, 10<sup>th</sup> edition, 2015.
2. Erwin Kreyszig, “Advanced Engineering Mathematics”, 10<sup>th</sup> edition, John Wiley & Sons, 2016.

### **Reference Books**

3. J. Stewart, “Essential Calculus”, Cengage, 2<sup>nd</sup> edition, 2017.
4. G.B. Thomas and R.L. Finney, “Calculus and Analytic geometry”, 9<sup>th</sup> Edition, Pearson, Reprint, 2002.
5. Peter O Neil, “Advanced Engineering Mathematics”, 7<sup>th</sup> Edition, Thomson, 2007.
6. Louis C Barret, C Ray Wylie, “Advanced Engineering Mathematics”, Tata McGraw Hill, 6<sup>th</sup> edition, 2003.
7. Veerarajan T, “Engineering Mathematics for first year”, Tata McGraw - Hill, 2008.
8. B.S. Grewal, “Higher Engineering Mathematics”, Khanna Publishers, 43 Edition, 2015.
9. Ronald N. Bracewell, “The Fourier Transform and its Applications”, McGraw – Hill International Editions, 2000.

### **COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                                                                                                                  | No of Lecture/Tutorial Hours |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
| 1   | <b>Module 1: Ordinary Differential Equations</b>                                                                                                       | 9                            |
| 1.1 | Homogenous linear equation of second order, Superposition principle, general solution.                                                                 | 1                            |
| 1.2 | Homogenous linear ODEs of second order with constant coefficients.                                                                                     | 2                            |
| 1.3 | Second order Euler-Cauchy equation.                                                                                                                    | 1                            |
| 1.4 | Non homogenous linear differential equations of second order with constant coefficient-solution by undetermined coefficients, variation of parameters. | 3                            |
| 1.5 | Higher order equations with constant coefficients.                                                                                                     | 2                            |
| 2   | <b>Module 2: Sequences and Series</b>                                                                                                                  | 9                            |
| 2.1 | Convergence of sequences and series, geometric and p-series.                                                                                           | 2                            |
| 2.2 | Test of convergence (comparison, ratio and root).                                                                                                      | 4                            |

|     |                                                                                                                |                 |
|-----|----------------------------------------------------------------------------------------------------------------|-----------------|
| 2.3 | Alternating series and Leibnitz test, absolute and conditional convergence                                     | 3               |
| 3   | <b>Module 3: Fourier series</b>                                                                                | 9               |
| 3.1 | Taylor series, Binomial series and series representation of exponential, trigonometric, logarithmic functions. | 3               |
| 3.2 | Fourier series, Euler formulas, Convergence of Fourier series (Dirichlet's conditions)                         | 3               |
| 3.3 | Half range sine and cosine series.                                                                             | 3               |
| 4   | <b>Module 4: Fourier Transforms</b>                                                                            | 9               |
| 4.1 | Fourier integral representation.                                                                               | 1               |
| 4.2 | Fourier Cosine and Sine integrals and transforms.                                                              | 2               |
| 4.3 | Complex Fourier integral representation, Fourier transform and its inverse transforms, basic properties.       | 3               |
| 4.4 | Fourier transform of derivatives, Convolution theorem                                                          | 3               |
| 5   | <b>Module 5: Laplace Transforms</b>                                                                            | 9               |
| 5.1 | Laplace Transform, inverse Transform, Linearity, First shifting theorem, transform of basic functions.         | 2               |
| 5.2 | Transform of derivatives and integrals.                                                                        | 1               |
| 5.3 | Solution of Differential equations, Initial value problems by Laplace transform method.                        | 2               |
| 5.4 | Unit step function - Second shifting theorem.                                                                  | 1               |
| 5.5 | Dirac Delta function and solution of ODE involving Dirac delta function.                                       | 2               |
| 5.6 | Convolution and related problems.                                                                              | 1               |
|     | <b>Total</b>                                                                                                   | <b>45 Hours</b> |

### CO ASSESSMENT QUESTIONS

**Course Outcome 1 (CO 1): Solve homogeneous and nonhomogeneous linear equation with constant coefficients.**

1. Find the general solution to  $2x^2 \frac{d^2 y}{dx^2} + x \frac{dy}{dx} - 3y = 0$  given that  $y_1(x) = \frac{1}{x}$  is a solution.
2. Solve the initial value problem  $x^2 y'' - 3xy' + 4y = 0$  given that  $y(1) = \pi, y'(1) = 4\pi$
3. By the method of undetermined coefficients, solve  $y'' - 2y' + y = e^x \cos 2x$

**Course Outcome 2 (CO 2): Perform various tests to determine whether a given series is convergent, absolutely convergent or conditionally convergent.**

1. Find the sum of the series  $\sum_{n=1}^{\infty} \frac{1}{9n^2+3n-2}$ , if it is convergent.
2. Examine the convergence of  $\sum_{n=1}^{\infty} \left( \frac{n}{n+1} \right)^{n^2}$

3. Determine whether the series  $\sum_{n=1}^{\infty} \frac{(-1)^n n^4}{4^n}$  is absolutely convergent.

**Course Outcome 3 (CO 3): Determine the power series expansion of a given function.**

1. Find the Taylor's series representation of  $f(x) = \sin \pi x$  about  $x = 1$
2. Determine the binomial series representation of  $\frac{1}{\sqrt{(2+x)^3}}$
3. Find the Fourier series of the periodic function  $f(x)$  of period 2, where
$$f(x) = \begin{cases} -1 & -1 \leq x \leq 0 \\ 2x & 0 \leq x \leq 1 \end{cases}$$
 and deduce that  $1 + \frac{1}{3^2} + \frac{1}{5^2} + \dots = \frac{\pi^2}{8}$ .

**Course Outcome 4 (CO 4): Determine the Fourier transforms of functions and apply them to solve problems arising in engineering .**

1. Find the Fourier integral representation of function defined by  $f(x) = e^{-x}$  for  $x > 0$  and  $f(x) = 0$  for  $x < 0$ .
2. What are the conditions for the existence of Fourier Transform of a function  $f(x)$  ?
3. Find the Fourier Transform of  $f(x) = x$  for  $|x| \leq 1$  and  $f(x) = 0$  otherwise.

**Course Outcome 5 (CO 5): Compute Laplace transform and apply them to solve ODEs arising in engineering.**

1. What is the inverse Laplace Transform of  $\frac{3s+2}{(s-1)(s^2+2s+5)}$ ?
2. Find the Laplace Transform of:
  - (i)  $e^{-t} \sin^2 t$
  - (ii)  $\delta(t-a)$
3. Solve the differential equation  $y'' + 4y = f(t)$ , with initial conditions  $y(0) = 1$  and  $y'(0) = 0$ , where

$$f(t) = \begin{cases} 0 & \text{if } 0 \leq t \leq 4 \\ 3 & \text{if } t \geq \pi \end{cases}$$

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

SECOND SEMESTER B.TECH DEGREE EXAMINATION, JUNE 2025

Course Code: B24MA1T02

Course Name: ORDINARY DIFFERENTIAL EQUATIONS AND TRANSFORMS Common to all  
branches

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Check whether  $x, \ln x$  are linearly independent or not.
2. Solve  $y''' + 9y' = 0$ .
3. Find the rational number represented by the repeating decimal 5.373737...
4. Examine the convergence of  $\sum_{k=1}^{\infty} \frac{1}{k!}$
5. Find the binomial series for  $f(x) = (1+x)^{\frac{1}{3}}$  upto third degree term.
6. Obtain the half range sine series expansion of  $f(x) = \pi x - x^2$  in  $(0, \pi)$ .
7. Find the cosine integral representation of the function  $f(x) = \begin{cases} 1 & ; 0 < x < 1 \\ 0 & ; x > 1 \end{cases}$
8. Find the Fourier cosine transform of  $e^{-x}$ ,  $x > 0$ .
9. Find the Laplace transform of  $\sin^2 2t$ .
10. Find  $L^{-1} \left\{ \frac{1}{(s-1)(s-2)} \right\}$ .

PART B

**Answer any one question from each module. Each question carries 14 marks.**

11. (a) Solve the initial value problem  $y'' + 9y = 0, y(0) = 0.2, y'(0) = -1.5$ . 7  
 (b) By the method of variation of parameters solve  $y'' + 4y = \tan 2x$ . 7

**OR**

12. (a) By the method of undetermined coefficients solve  $y'' + 2y' + 4y = 3e^{-x}$ . 7  
 (b) Solve  $x^2y'' + xy' + 9y = 0, y(1) = 0, y'(1) = 2.5$ . 7

**OR**

14. (a) Determine whether the series  $\sum_{k=1}^{\infty} \frac{1}{\sqrt{k+1}}$  is absolutely convergent or conditionally convergent. 7

(b) Test the convergence of

(i)  $\sum_{k=1}^{\infty} \frac{k!}{3!(k-1)!3^k}$

(ii)  $\sum_{k=1}^{\infty} \left(\frac{4k-5}{2k+1}\right)^k$

15. (a) Expand into a Fourier series,  $f(x) = e^{-x}, 0 < x < 2\pi$ . 7

- (b) Obtain the half range Fourier sine series of  $f(x) = \begin{cases} x & , 0 < x < \frac{\pi}{2} \\ \pi - x & , \frac{\pi}{2} < x < \pi \end{cases}$  7

**OR**

16. (a) Find the Fourier series expansion of  $f(x) = x^2$  in the interval  $-\pi < x < \pi$ .  
 Hence show that  $1 - \frac{1}{2^2} + \frac{1}{3^2} - \frac{1}{4^2} + \dots = \frac{\pi^2}{12}$ . 7

- (b) Find the half range cosine series for  $f(x) = (x-1)^2$  in  $0 \leq x \leq 1$ . 7

17. (a) Find the Fourier transform of  $f(x) = \begin{cases} 1 & \text{if } |x| < 1 \\ 0 & \text{otherwise} \end{cases}$  7

- (b) Find the Fourier sine integral of  $f(x) = \begin{cases} \sin x & , 0 \leq x \leq \pi \\ 0 & , x > \pi \end{cases}$  7

**OR**

18. (a) Using Fourier integral representation show that  $\int_0^{\infty} \frac{\cos wx}{1+w^2} dw = \frac{\pi}{2} e^{-x}, x > 0$ . 7

- (b) Find the Fourier sine transform of  $f(x) = \begin{cases} k & , 0 < x < a \\ 0 & , x > a \end{cases}$  7

19. (a) Find the Laplace transform of

(i)  $t \sin 2t$

(ii)  $e^{-t} \sin 3t \cos 2t$  7

- (b) Using convolution theorem find  $L^{-1} \left\{ \frac{1}{s(s^2+4)} \right\}$  7

**OR**

20. (a) Find  $L^{-1} \left\{ \frac{4s+5}{(s+2)(s-1)^2} \right\}$  7

- (b) Use Laplace transform to solve  $y'' + 2y' + 2y = 0, y(0) = y'(0) = 1$ . 7



| B24ES1T03A | COMPUTER<br>AIDED<br>ENGINEERING<br>GRAPHICS (A) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|------------|--------------------------------------------------|---|---|---|---|--------|-------------------------|
|            |                                                  | 2 | 0 | 2 | 4 | 3      | 2024                    |

### Preamble

This course aims to equip students with the skills for precise technical communication using global standards. Through this course, students learn to proficiently use CAD software and interpret engineering drawings accurately. Emphasis is placed on conveying design intent and specifications effectively. By mastering these skills, students develop a critical eye for detail and enhance their ability to communicate complex engineering concepts visually. Ultimately, the course prepares students to excel in the global engineering landscape by fostering proficiency in graphical communication and CAD expertise.

### Prerequisites

Nil

### Course Outcomes

After the completion of the course the student will be able to:

|      |                                                                                                                                                                            |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Draw the projection of points and lines located in different quadrants. (Cognitive Knowledge Level: Analyse)                                                               |
| CO 2 | Prepare multi view orthographic projections of objects by visualizing them in different positions. (Cognitive Knowledge Level: Apply)                                      |
| CO 3 | Draw sectional views and develop surfaces of a given object. (Cognitive Knowledge Level: Apply)                                                                            |
| CO 4 | Familiarize the tools and features of CAD software (Cognitive Knowledge Level: Understand)                                                                                 |
| CO 5 | Prepare pictorial drawings using the principle of isometric projections and convert 3D views to orthographic views using CAD Software (Cognitive Knowledge Level: Analyse) |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    | 2    | 2    |      |      | 1    |      | 1    |       | 1     |
| CO 2 | 3    | 2    | 2    | 2    |      |      | 1    |      | 1    |       | 1     |
| CO 3 | 3    | 2    | 2    | 2    |      |      | 1    |      | 2    |       | 1     |
| CO 4 | 3    | 1    | 1    | 1    | 2    |      | 1    |      | 2    |       | 1     |
| CO 5 | 3    | 2    | 2    | 2    | 2    |      | 1    |      | 2    |       | 1     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         |                       |                 |                                    |
| Understand       | 40                    | 40              | 30                                 |
| Apply            | 30                    | 30              | 40                                 |
| Analyse          | 30                    | 30              | 30                                 |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 100       | 50        | 2 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 20 marks |
| Continuous Assessment Test (2 numbers) | 40 marks |
| Assignment/Class work                  | 30 marks |
| Self Study                             | 10 marks |

Continuous Assessment Test 1 will have 20 marks and will be from Part A. Test 2 will be from Part B and will also carry 20 marks. Regarding Assignments/Class work, 15 marks will be awarded for Part A and the remaining 25 marks should be based on class works/assignments from Part B (minimum 5 exercises).

## **End Semester Examination Pattern**

ESE will have questions only from Part A and with a duration of 2-hours. The exam will be for 50 marks and will have to be drawn on A4 size answer booklets. The question paper shall contain two parts; Part I contains three questions, one question each from the three modules, each carrying 12 marks. Part II contains two questions (from any of the three modules) carrying 14 marks each. The student has to answer all the three questions from Part I and any one question from Part II.

### **SYLLABUS**

#### **PART A**

#### **MODULE 1 (11 hours)**

##### **Introduction:**

Relevance of technical drawing in engineering field. Types of lines, Dimensioning, BIS code of practice for technical drawing.

##### **Orthographic projection of Points and Lines:**

Projection of points in different quadrants, Projection of straight lines inclined to one plane and inclined to both planes. Trace of line. Inclination of lines with reference planes True length of line inclined to both the reference planes.

#### **MODULE 2 (10 hours)**

##### **Orthographic projection of Solids:**

Projection of Simple solids such as Triangular, Rectangle, Square, Pentagonal and Hexagonal Prisms, Pyramids, Cone and Cylinder. Projection of solids in simple position. Projection of solids with axis inclined to one of the reference planes and both reference planes.

#### **MODULE 3 (10 hours)**

##### **Sections of Solids:**

Sections of Prisms, Pyramids, Cone, Cylinder with axis in vertical position and cut by different section planes. True shape of the sections.

##### **Development of Surfaces:**

Development of surfaces of the Prisms, Pyramids, Cone, Cylinder cut by different section planes.

**PART B**

**MODULE 4 (6 hours)**

**Introduction to Computer Aided Drawing:**

Role of CAD in design and development of new products, Advantages of CAD- Create a new drawing, Set model environment i.e., units, limits etc., Set interface settings e.g., snap, grid, ortho, Create and save an AutoCAD drawing template, Use zooming tools, Drawing commands as line, spline, circle, arc, rectangle, polygon, ellipse, Hatch a closed entity to represent sections, Erase & oops, Copy and Move objects, Rotate, Scale, Stretch Extend & Offset, Mirror and array, Apply Chamfers and Fillets, Edit polylines and spline, decurve, fit, thickness join & explode, Trim, break, explode, Create layers and assign properties as line weights, line types, colour, Modify status: On, Off, Freeze, Thaw, Lock, Unlock, Set layer current, Modify layer attributes, Text and Dimensions, Plotting, Extrusion.

**MODULE 5 (8 hours) Isometric Projection using CAD:**

Isometric View and Projections of Prisms, Pyramids, Cone, Cylinder, Frustum of Pyramid, Frustum of Cone.

**Conversion of Pictorial Views using CAD:**

Creating two-dimensional drawing from pictorial views.

**Text Books**

1. Bhatt, N.D., Engineering Drawing, Charotar Publishing House Pvt. Ltd.
2. John, K.C. Engineering Graphics, Prentice Hall India Publishers.
3. K.N. Anilkumar, Engineering Graphics, Adhyuth Narayan Publishers.
4. P. I. Varghese, Engineering Graphics, Tata McGraw Hill Education.

**Reference Books**

1. Agrawal, B. and Agrawal, C.M., Engineering Drawing, Tata McGraw Hill Publishers.
2. Duff, J.M. and Ross, W.A., Engineering Design and Visualisation, Cengage Learning.
3. Kulkarni, D.M., Rastogi, A.P. and Sarkar, A.K., Engineering Graphics with AutoCAD, PHI.
4. Luzaddff, W.J. and Duff, J.M., Fundamentals of Engineering Drawing, PHI.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                                                                                                                                                                                    | No of Lecture/Tutorial Hours |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | Total Hours                                                                                                                                                                                                              | 45 Hours                     |
|     | <b>Module 1: Introduction and Orthographic projection of Points and Lines</b>                                                                                                                                            | 11                           |
| 1.1 | Relevance of technical drawing in Engineering field. Types of lines, Dimensioning, BIS code of practice for technical drawing.                                                                                           | 1                            |
| 1.2 | Concept of principle planes of projection, different quadrants, locating points on different quadrants                                                                                                                   | 2                            |
| 1.3 | Projection of lines, inclined to one plane and Lines inclined to both planes.                                                                                                                                            | 4                            |
| 1.4 | Problems on lines using trapezoid method .                                                                                                                                                                               | 2                            |
| 1.5 | Line rotation method of solving, problems on line rotation method.                                                                                                                                                       | 2                            |
|     | <b>Module 2: Orthographic projection of Solids</b>                                                                                                                                                                       | 10                           |
| 2.1 | Introduction of different solids, Simple position plan and elevation of solids.                                                                                                                                          | 3                            |
| 2.2 | Problems on views of solids inclined to one plane.                                                                                                                                                                       | 2                            |
| 2.3 | Problems on views of solids inclined to both planes.                                                                                                                                                                     | 3                            |
| 2.4 | Practice problems on solids inclined to both planes.                                                                                                                                                                     | 2                            |
|     | <b>Module 3: Sections of solids and development of surfaces</b>                                                                                                                                                          | 10                           |
| 3.1 | Introduction to section planes. Principle of locating cutting points and finding true shape.                                                                                                                             | 2                            |
| 3.2 | Problems on sections of different solids and Problems when the true shape is given.                                                                                                                                      | 3                            |
| 3.3 | Principle and development of simple solids.                                                                                                                                                                              | 2                            |
| 3.4 | Development of solids and sectioned solids.                                                                                                                                                                              | 3                            |
|     | <b>Module 4: Introduction to Computer Aided Drawing</b>                                                                                                                                                                  | 6                            |
| 4.1 | Role of CAD in design and development of new products, Advantages of CAD                                                                                                                                                 | 1                            |
| 4.2 | AutoCAD Fundamentals: Open, (and close) AutoCAD application, Create a new drawing, Set model environment ie units, limits etc, Set interface settings eg snap, grid, ortho, Create and save an AutoCAD drawing template. | 1                            |

|     |                                                                                                                                                                                                                                                                                                                                                |   |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 4.3 | Use zooming tools, Drawing commands as line, spline, circle, arc, rectangle, polygon, ellipse, Hatch a closed entity to represent sections, Erase & oops, Copy and Move objects, Rotate, Scale, Stretch Extend & Offset, Mirror and array, Apply Chamfers and Fillets, Edit polylines and spline, de-curve, fit, thickness join & explode<br>. | 2 |
| 4.4 | Trim, break, explode, Create layers and assign properties as line weights, line types, colour, Modify status: On, Off, Freeze, Thaw, Lock, Unlock, Set layer current, Modify layer attributes, Text and Dimensions, Plotting, Extrusion.<br>.                                                                                                  | 2 |
|     | <b>Module 5: Isometric Projection using CAD</b>                                                                                                                                                                                                                                                                                                | 8 |
| 5.1 | Isometric View and Projections of Prisms, Pyramids, Cone, Cylinder.                                                                                                                                                                                                                                                                            | 3 |
| 5.2 | Isometric View and Projections of Frustum of Pyramid, Frustum of Cone..                                                                                                                                                                                                                                                                        | 2 |
| 5.3 | Creating two-dimensional drawing from pictorial views..                                                                                                                                                                                                                                                                                        | 3 |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Locate points in different quadrants as per given conditions.
2. Problems on lines inclined to both planes.
3. Find True length, Inclinations and Traces of lines.

#### Course Outcome 2 (CO 2):

1. Draw orthographic views of solids and combination solids .
2. Draw views of solids inclined to any one reference plane.
3. Draw views of solids inclined to both reference planes.

#### Course Outcome 3 (CO 3):

1. Draw views of solids sectioned by a cutting plane.



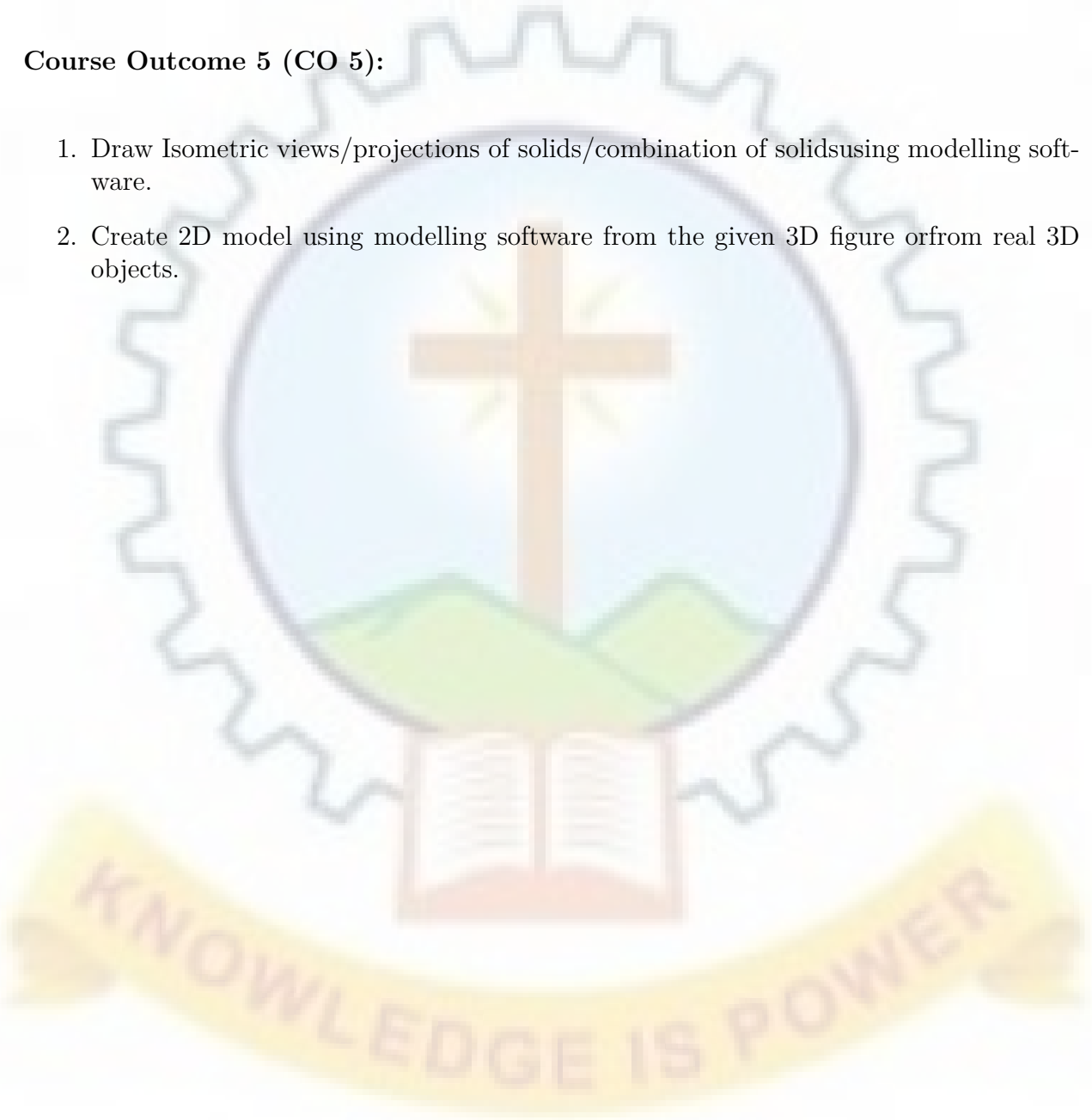
2. Find location and inclination of cutting plane given true shape of the section.
3. Draw development of lateral surface of solids and also its sectioned views.

**Course Outcome 4 (CO 4):**

1. Draw the given figure including dimensions using 2D software.

**Course Outcome 5 (CO 5):**

1. Draw Isometric views/projections of solids/combination of solids using modelling software.
2. Create 2D model using modelling software from the given 3D figure or from real 3D objects.



MODEL QUESTION PAPER

QP CODE:

Pages: 1

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

SECOND SEMESTER B.TECH DEGREE EXAMINATION, JUNE 2025

Course Code: B24ES1T03A

Course Name: COMPUTER AIDED ENGINEERING GRAPHICS (A)

Max. Marks: 50

Duration: 2 hours

**Instructions: Retain construction lines. Show necessary dimensions.**

**PART I**

**Answer all questions. Each question carries 12 marks.**

1. The end point A of a line is 20mm above HP and 10mm in front of VP. The other end of the line is 50mm above HP and 15mm behind VP. The distance between the end projectors is 70mm. Draw the projections of the line. Find the true length and true inclinations of the line with the principal planes.
2. A pentagonal pyramid of base side 25mm and height 40mm, is resting on the ground on one of its triangular faces. The base edge of that face is inclined  $30^\circ$  to VP. Draw the projections of the solid.
3. Draw the development of a pentagonal pyramid of base side 30mm and height 50mm. A string is wound from a corner of the base round the pyramid and back to the same point through the shortest distance. Show the position of the string in the elevation and plan.

**PART II**

**Answer any one full question. Each question carries 14 marks.**

4. A triangular prism of base side 40mm and height 70mm is resting with its base on the ground and having an edge of the base perpendicular to VP. Section the solid such that the true shape of the section is a trapezium of parallel sides 30mm and 10mm. Draw the projections showing the true shape. Find the inclination of the cutting plane with the ground plane.
5. A hexagonal prism of base edge 25 mm and height 60 mm is resting on one of its base edges on HP. Draw its projection if the rectangular face carrying that base edge is inclined  $35^\circ$  to HP and the base edge at which it is resting is inclined  $40^\circ$  to VP.

| B24EC1T02 | ELECTRICAL<br>CIRCUIT<br>THEORY | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|---------------------------------|---|---|---|---|--------|-------------------------|
|           |                                 | 3 | 1 | 0 | 5 | 4      | 2024                    |

### Preamble

This course aims to equip the students with an understanding of basic circuit elements and enables the student to analyze electrical circuits.

### Prerequisites

Nil

### Course Outcomes

After the completion of the course the student will be able to:

|      |                                                                                                       |
|------|-------------------------------------------------------------------------------------------------------|
| CO 1 | Apply fundamental concepts and circuit laws to solve simple DC electric circuits [Understand , Apply] |
| CO 2 | Develop and solve DC circuits using circuit analysis and network theorems [Apply, Analyze]            |
| CO 3 | Apply the fundamental laws of electrical engineering to solve simple ac circuits [Apply, Analyze]     |
| CO 4 | Analyze the complex impedance components and solve the ac circuits [Apply, Analyze]                   |
| CO 5 | Examine the magnetic circuits and its working [Understand, Apply, Analyze]                            |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    | 3    | 2    |      | 1    |      |      |      |       | 3     |
| CO 2 | 3    | 2    | 3    | 2    |      | 1    |      |      |      |       | 3     |
| CO 3 | 3    | 2    | 3    | 2    |      | 1    |      |      |      |       | 3     |
| CO 4 | 3    | 2    | 3    | 2    |      | 1    |      |      |      |       | 3     |
| CO 5 | 3    | 2    | 3    | 2    |      | 1    |      |      |      |       | 3     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         |                       |                    |                                       |
| Understand       | 30                    | 30                 | 30                                    |
| Apply            | 20                    | 20                 | 20                                    |
| Analyse          | 50                    | 50                 | 50                                    |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions carrying 3 marks each. Part B contains 2 questions from each module out of which 1 to be answered. Each question carries 14 mark and can have maximum 2 sub- divisions.

## SYLLABUS

### MODULE 1 (7 hours)

**Fundamental Concepts of Circuit Elements and Circuit variables:** Charge, current, voltage, electromotive force and power. Resistors, Capacitors Inductors- terminal V-I relations.

**Voltage and Current sources :** Real and Ideal independent voltage and current sources, V-I relations, voltage and current division, source transformation, Star-Delta Transformation.

### MODULE 2 ( 9 hours)

**Voltage and Current Laws :** Equivalent R,L,C in series and parallel combination, Kirchhoff's Voltage Law, Kirchhoff's Current Law, Mesh Analysis, Nodal Analysis, Thevenin's theorem and Norton's theorem.

### MODULE 3 ( 10 hours)

**Alternating current fundamentals :** Generation of Alternating voltages-waveforms, Frequency, Period, RMS and average values, peak factor and form factor of periodic waveforms and composite waveforms, Numerical problems, Phasor Concepts, Complex representation (polar and rectangular forms) of sinusoidal voltages and currents, phasor diagrams, Average Power, Power factor.

### MODULE 4 (9 hours)

**Complex impedance:** series and parallel impedances and admittances, Phasor analysis of series RL, RC, RLC circuits, active, reactive and apparent power, Simple numerical problems.

**Basic Circuit Laws applied on AC circuits:** Kirchhoff's current and voltage laws, mesh analysis and node analysis. Power and power factor – solution of RLC series and parallel circuits.

### MODULE 5 (10 hours)

**Magnetic Circuits :** Magneto motive force, flux, reluctance, permeability -comparison of electric and magnetic circuits, analysis of series magnetic circuits, Parallel magnetic circuits,

numerical problems, self and mutual inductance – coupling coefficient. Transformer – principle of operation – EMF equation, losses and efficiency, Three phase system – generation of three phase voltage – star and delta system and its relation between line and phase voltages and currents – phasor representation of three phase system - balanced delta connected system.

**Text Books**

1. Engineering circuit analysis (Seventh Edition) by William H. Hayt, Jr., Jack E. Kemmerly, Steven M. Durbin.
2. Charles K Alexander and Mathew N O Sadiku, Fundamentals of Electric Circuits, Tata McGraw-Hill, 3rd Ed, 2009.

**Reference Books**

1. Kothari and Nagrath, Basic Electrical Engineering, Tata McGraw Hill, 2nd Edition, 2006.
2. Basic Electrical Engineering, SK Sahadev, Khanna Book Publishing .



**COURSE CONTENTS AND LECTURE SCHEDULE**

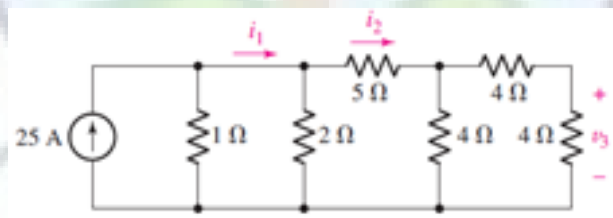
| No  | Topic                                                                                                                                 | No of Lecture/Tutorial Hours |
|-----|---------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                       | <b>7</b>                     |
| 1.1 | Fundamental Concepts of Circuit Elements and Circuit variables: Charge, current, voltage, electromotive force and power.              | 1                            |
| 1.2 | Resistors, Capacitors Inductors- terminal V-I relations.                                                                              | 1                            |
| 1.3 | Voltage and Current sources - Real and Ideal independent voltage and current sources, V-I relations                                   | 1                            |
| 1.4 | voltage and current division, source transformation                                                                                   | 2                            |
| 1.5 | Star-Delta Transformation.                                                                                                            | 2                            |
|     | <b>Module 2</b>                                                                                                                       | <b>9</b>                     |
| 2.1 | Equivalent R,L,C in series and parallel combination                                                                                   | 2                            |
| 2.2 | Kirchoff's Voltage Law, Kirchoff's Current Law, Mesh Analysis                                                                         | 2                            |
| 2.3 | Nodal Analysis                                                                                                                        | 2                            |
| 2.4 | Thevinin's theorem                                                                                                                    | 2                            |
| 2.5 | Norton's theorem                                                                                                                      | 1                            |
|     | <b>Module 3</b>                                                                                                                       | <b>10</b>                    |
| 3.1 | Generation of Alternating voltages-waveforms, Frequency, Period, RMS and average values                                               | 2                            |
| 3.2 | Peak factor and form factor of periodic waveforms and composite waveforms                                                             | 2                            |
| 3.3 | Numerical problems, Phasor Concepts                                                                                                   | 2                            |
| 3.4 | Complex representation (polar and rectangular forms) of sinusoidal voltages and currents phasor diagrams, Average Power, Power factor | 4                            |
|     | <b>Module 4</b>                                                                                                                       | <b>9</b>                     |
| 4.1 | Series and parallel impedances and admittances                                                                                        | 1                            |
| 4.2 | Phasor analysis of series RL, RC, RLC circuits, active, reactive and apparent power, Simple numerical problems                        | 4                            |
| 4.3 | Basic Circuit Laws applied on AC circuits: Kirchhoff's current and voltage laws, mesh analysis and node analysis                      | 3                            |
| 4.4 | Power and power factor – solution of RLC series and parallel circuits.                                                                | 1                            |
|     | <b>Module 5</b>                                                                                                                       | <b>10</b>                    |
| 5.1 | Magnetic Circuits: Magneto motive force, flux, reluctance, permeability                                                               | 1                            |
| 5.2 | Comparison of electric and magnetic circuits, analysis of series magnetic circuits, Parallel magnetic circuits, numerical problems    | 2                            |
| 5.3 | self and mutual inductance – coupling coefficient                                                                                     | 2                            |

|     |                                                                                                                                                                                                                              |                 |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 5.4 | Transformer – principle of operation – EMF equation, losses and efficiency                                                                                                                                                   | 2               |
| 5.5 | Three phase system – generation of three phase voltage – star and delta system and its relation between line and phase voltages and currents – phasor representation of three phase system - balanced delta connected system | 3               |
|     | <b>Total Hours</b>                                                                                                                                                                                                           | <b>45 Hours</b> |

### CO ASSESSMENT QUESTIONS

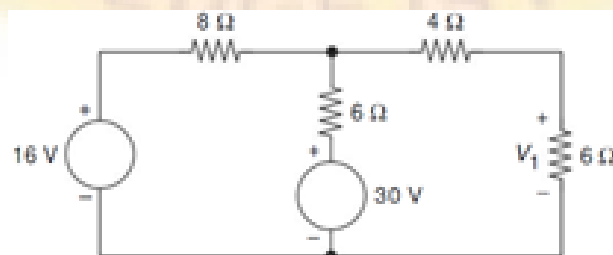
#### Course Outcome 1 (CO 1):

1. A capacitor is fabricated from two thin aluminum discs with 1 cm diameter separated by 150  $\mu$ m, with air in between. Calculate its capacitance. What voltage should be applied across this capacitor to store 1 mJ of energy?
2. Employing resistance combination and current division as appropriate, determine values for  $i_1, i_2$ , and  $v_3$  in the circuit.

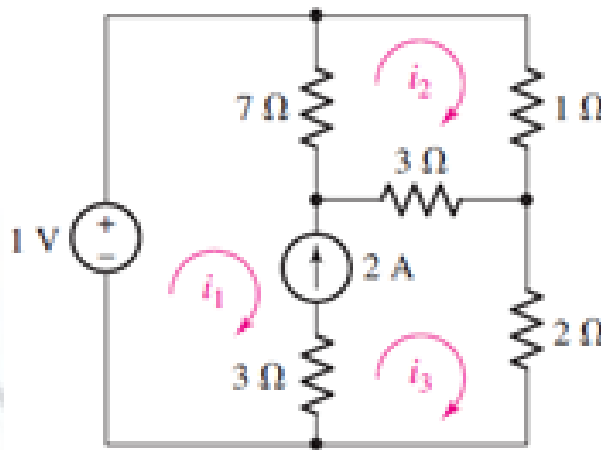


#### Course Outcome 2 (CO 2):

1. Find the voltage  $V_1$  across the 6ohm resistance using (i) nodal method, and (ii) mesh method of circuit analysis.



2. Determine values for the three mesh currents

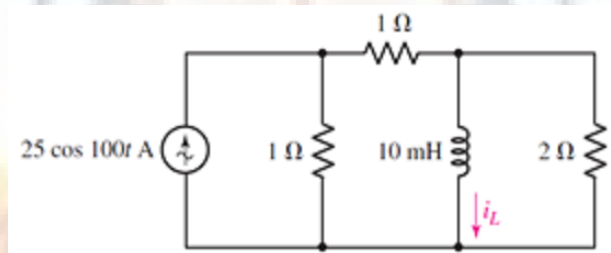


**Course Outcome 3 (CO 3):**

1. Find the average and rms value of a saw tooth waveform of period T seconds.
2. A coil connected to 100 V DC supply draws 10 and the same coil when connected to 100 V, AC voltage of frequency 50 Hz draws 5 A. Calculate the parameters of the coil and power factor.

**Course Outcome 4 (CO 4):**

1. A coil resistance 10 and inductance 0.14 H is connected in series with a capacitor of 150 F across a 200 V, 50 Hz supply. Calculate (i) inductive reactance, (ii) capacitive reactance, (iii) impedance, (iv) current, and (v) voltage across coil and capacitor.
2. Calculate the power dissipated in the 2 ohm resistor assuming there are no transients present. Express your answer in terms of a single sinusoidal function.



**Course Outcome 5 (CO 5):**

1. The design requirements of an 11000/415 V, 50 Hz single-phase core type transformer are approximate emf/turn 15 V, maximum flux density 1.5 T. Find suitable number of primary and secondary turns and net cross-sectional area of core.
2. A 230/110 V single-phase transformer has a core loss of 100 W. If the input under no-load condition is 400 VA, find core loss current, magnetizing current, and no-load power factor angle.

MODEL QUESTION PAPER

QP CODE:

Pages: 5

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

SECOND SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: B24EC1T02

Course Name: ELECTRICAL CIRCUIT THEORY

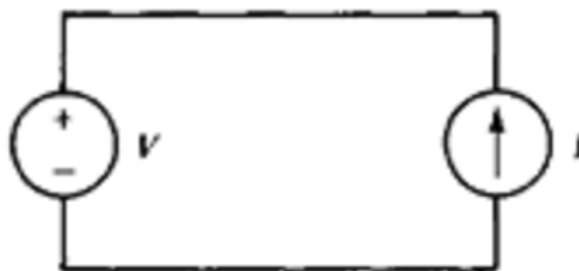
Max. Marks: 100

Duration: 3 hours

PART A

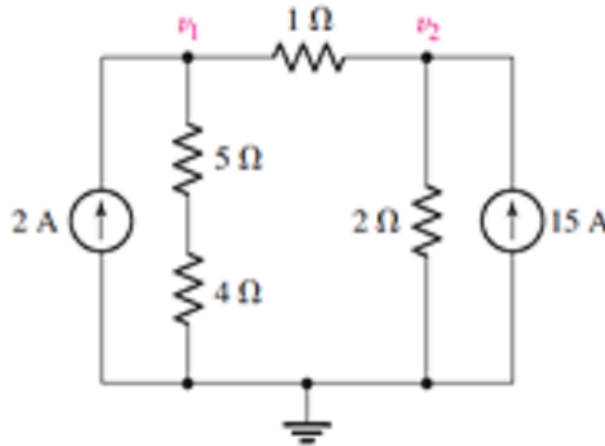
Answer all questions. Each question carries 3 marks

1. A battery is measured to have an open-terminal voltage of 14.2 V. When this voltage is connected to a 100 ohm load, the voltage measured between the terminals of the battery drops to 6.8 V. Determine the internal resistance of the battery.
2. A voltage source of V volts is connected to a current source of I amperes as shown. Find the power absorbed by the voltage source if  $V = -6V$  and  $I = 4 A$ .

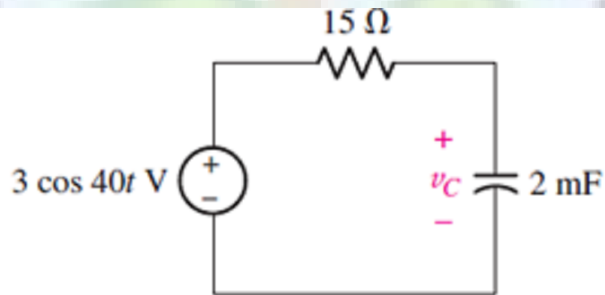


3. Show how to combine four 100 ohm resistors to obtain an equivalent resistance of 60 ohm.

4. Find  $v_1$  and  $v_2$  using nodal analysis.



5. Our houses are supplied with alternating voltage whose instantaneous value is given by the equation  $V = 325\sin(\omega t)$ , but we always say that AC voltage at home is 230 V. How do you explain this difference?
6. Distinguish between form factor and peak factor.
7. Define true power, apparent power, and reactive power and draw the power triangle.
8. Obtain an expression for  $v_c$ , in terms of a single sinusoidal function. You may assume all transients have died out long before  $t = 0$ .



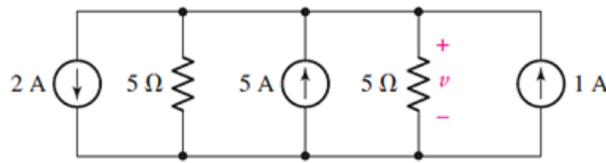
9. A balanced three-phase system with a line voltage of 300 V is supplying a balanced Y-connected load with 1200 W a leading PF of 0.8. Find the line current.
10. The emf per turn for a single-phase 2310/220 V, 50 Hz transformer is approximately 13 volt. Calculate the number of primary and secondary turns.

### PART B

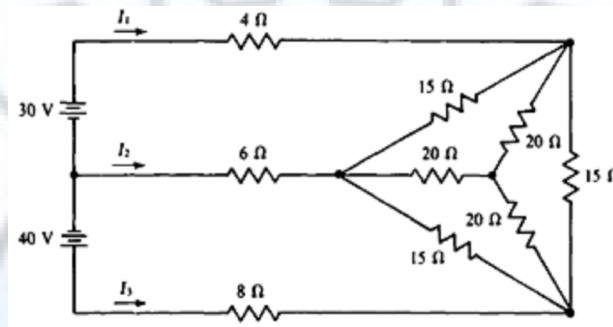
**Answer any one question from each module. Each question carries 14 marks**

### Module I

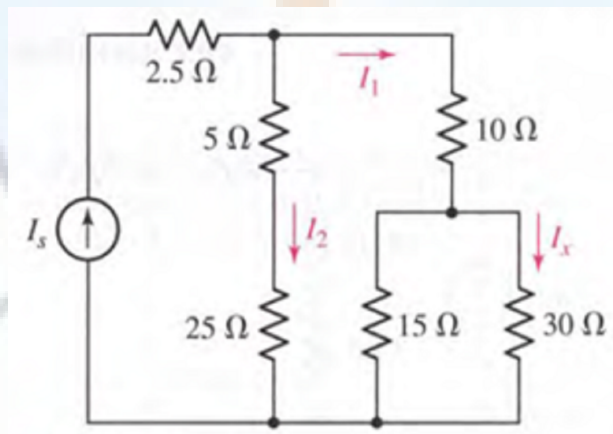
11. a) Find the power delivered by the 2A source to the rest of the circuit. (7 Marks)



- b) Find the currents  $I_1, I_2, I_3$  (7 Marks)

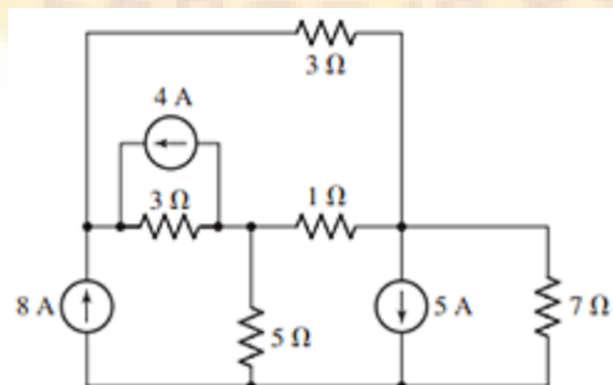


12. For the given circuit, find (i)  $I_x$  if  $I_1$  is  $12mA$  (ii)  $I_1$  if  $I_x$  is  $12mA$  (iii)  $I_x$  if  $I_2$  is  $15mA$  (iv)  $I_x$  if  $I_s$  is  $60mA$  (14 Marks)



### Module II

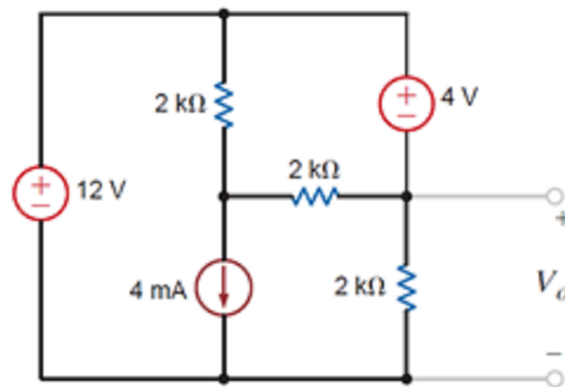
13. a) Determine the voltage across the 5 ohm resistor in the circuit and also calculate the power dissipated by the 7 ohm resistor. (8 Marks)





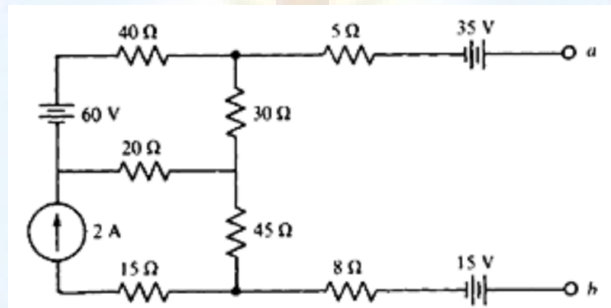
b) Find  $V_o$  using nodal analysis

(6 Marks)



14. Determine the Thevenin and Norton equivalent circuit across the terminals a-b

(14 Marks)



### Module III

15. a) Three sinusoidal voltages acting in series are given by  $v_1 = 10\sin(440t)$ ,  $v_2 = 10\sqrt{2}\sin(440t - 45^\circ)$ ,  $v_3 = 20\cos(440t)$ . Find an expression for the resultant voltage, and then find its frequency and rms value.

(7 Marks)

b) Calculate the average value and rms value of a periodic current wave having values for equal time interval changing suddenly from one value to next: 0, 30, 45, 70, 90, 70, 45, 30, 0, -30, -45, -70, etc. in ampere. What would be the average and the rms value of a sine wave having the same peak value?

(7 Marks)

16. a) Find the rms value, average value, and form factor of the voltage waveform.

(7 Marks)

b) Two AC voltages  $v_1(t) = 30\sin(314t + 45^\circ)$  and  $v_2(t) = 60\sin(314t + 60^\circ)$  are kept in series. Find the resultant voltage  $v(t)$  and express in the form  $v(t) = V_m\sin(314t \pm \phi)$

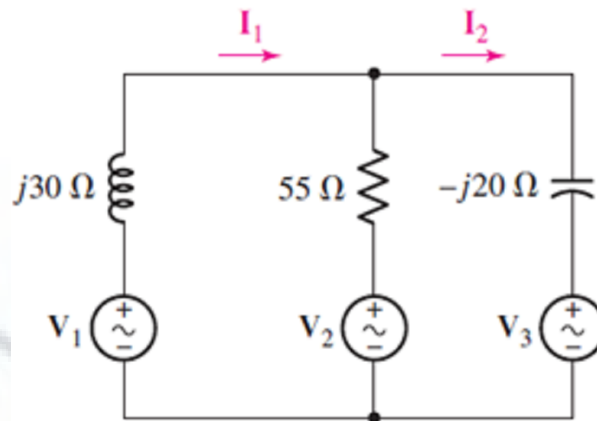
(7 Marks)

### Module IV

17. a) A coil having a resistance of 12 ohms and an inductance of 0.1 H is connected across a 100 V, 50 Hz supply. Calculate the (i) reactance and impedance of the coil, (ii) current, (iii) phase difference between the current and the applied voltage, and (iv) power factor. Draw also the phasor diagram showing voltage and current.

(8 Marks)

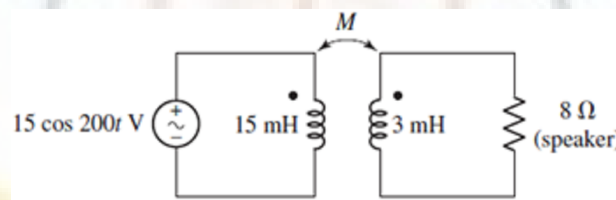
- b) Find  $I_1$  and  $I_2$  given  $V_1 = 10\angle -80^\circ\text{V}$ ,  $V_2 = 4\angle -0^\circ\text{V}$  and  $V_3 = 2\angle -23^\circ\text{V}$   
(6 Marks)



18. An inductive coil takes 10 A and dissipates 1,000 W when connected to a 250 V, 25 Hz supply. Calculate the (i) impedance, (ii) effective resistance, (iii) reactance, (iv) value of the capacitance required to be connected in series with coil to make the power factor of the circuit unity, and (vi) current taken by the coil after connecting capacitor. Further, draw the phasor diagram of the two cases. (14 Marks)

#### Module V

19. a) Three 100 ohm resistors are connected first in star and then in delta across 415 V, three-phase supply. Calculate the line and phase currents in each case and also the power taken from the source. (7 Marks)  
b) For the below circuit, determine for what value of M results in 1 W of average power being delivered to the speaker? (7 Marks)



20. a) A three-phase, 400 V supply is connected to a three-phase star-connected balanced load. The line current is 20 A and the power consumed by the load is 12 kW. Calculate the impedance of the load, phase current, and power factor. (7 Marks)  
b) Estimate the number of AT necessary to produce a flux of 1,00,000 lines round an iron ring of  $6\text{cm}^2$  cross section and 20 cm mean diameter having an air gap 2 mm wide across it. The permeability of the iron may be taken as 1,200. Neglect the leakage flux outside the 2 mm air gap. (7 Marks)

| B24EC1T03 | LOGIC CIRCUIT<br>DESIGN | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|-------------------------|---|---|---|---|--------|-------------------------|
|           |                         | 2 | 1 | 0 | 4 |        |                         |

**Preamble:**

The objective of the course is to 1) familiarize students with the basic concepts of Boolean algebra and digital systems 2) enable students to design simple combinational and sequential logic circuits 3) familiarize the representation of Binary and BCD (Binary Coded Decimal) numbers which in turn are helpful in understanding organization & design of a computer system.

**Prerequisites:**

NIL

**Course Outcomes:**

After the completion of the course the student will be able to:

|             |                                                                                                                                                                      |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Compare various positional number systems and binary codes (Cognitive Knowledge Level : Understand)                                                                  |
| <b>CO 2</b> | Simplify a given Boolean Function and design a combinational circuit to implement the simplified function using logic gates (Cognitive Knowledge Level : Understand) |
| <b>CO 3</b> | Learn to analyze and understand the behavior of combinational digital circuits (Cognitive Knowledge Level : Apply)                                                   |
| <b>CO 4</b> | Design a sequential logic circuit using the basic building blocks like flip-flops (Cognitive Knowledge Level : Apply)                                                |
| <b>CO 5</b> | Compare different logic families with respect to efficiency and performance (Cognitive Knowledge Level : Understand)                                                 |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 3    |      |      |      |      |      |      |      |       | 1     |
| <b>CO 2</b> | 3    | 3    | 3    | 2    |      |      |      |      |      |       | 1     |
| <b>CO 3</b> | 3    | 3    | 3    | 2    |      |      |      |      |      |       | 1     |
| <b>CO 4</b> | 3    | 3    | 3    | 2    |      |      |      |      |      |       | 1     |
| <b>CO 5</b> | 3    | 3    | 3    | 2    |      |      |      |      |      |       | 1     |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                     | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|---------------------|---------------------------------------|
|                  | Test 1<br>(% Marks)   | Test 2<br>(% Marks) |                                       |
| Remember         | 10                    | 10                  | 10                                    |
| Understand       | 20                    | 20                  | 30                                    |
| Apply            | 20                    | 20                  | 60                                    |
| Analyse          |                       |                     |                                       |
| Evaluate         |                       |                     |                                       |
| Create           |                       |                     |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Quiz/Course Project         | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions carrying 3 marks each. Part B contains 2 questions from each module out of which 1 to be answered. Each question carries 14 mark and can have maximum 2 sub- divisions.

## SYLLABUS

### MODULE 1 (7 hours)

#### Number Systems

Decimal, Binary, Octal and Hexadecimal Number Systems- Number Base Conversions. Addition, Subtraction, Multiplication and Division of binary numbers. Addition and subtraction of BCD, Octal and Hexadecimal numbers. Representation of negative numbers- Complements, Subtraction with complements. Binary coded decimal codes; Gray codes; Excess 3 code. Alphanumeric codes: ASCII.

## **MODULE 2 (8 hours)**

### **Boolean Algebra and Karnaugh Maps**

Postulates of Boolean Algebra. Basic theorems and Properties of Boolean Algebra. Minimization of Boolean expressions, Sum of Products (SOP), Product of Sums (POS) - Canonical and Standard forms. Simplification of Boolean Functions- Using Karnaugh- Map Method (upto five variables), Don't care conditions, Product of sums simplification, Tabulation Method.

## **MODULE 3 (8 hours)**

### **Combinational Circuits**

Combinatorial Logic Systems - Binary adders and subtractors-Half adder, Full adder, Half Subtractor, Full Subtractor, Binary Parallel adder, Carry look ahead adder, BCD adder, Comparators – one bit and two bit, Multiplexers-Implementation of combinational circuits using Multiplexers, Demultiplexers, Encoder, Decoder, Code converter-Binary to Gray, BCD to Excess 3.

## **MODULE 4 (7 hours)**

### **Sequential Circuits**

Building blocks like S-R, JK and Master-Slave JK FF, Edge triggered FF, Conversion of Flipflops, Excitation table and characteristic equation. Shift registers-SIPO, SISO, PISO, PIPO. Shift Registers with parallel Load/Shift, Ring counter and Johnsons counter. Asynchronous and Synchronous counter design, Mod N counter, Up- down counter, BCD counter.

## **MODULE 5 (6 hours)**

### **TTL and CMOS**

TTL, ECL, CMOS - Electrical characteristics of logic gates – logic levels and noise margins, fan-out, propagation delay, transition time, power consumption and power-delay product. TTL inverter - circuit description and operation; CMOS inverter - circuit description and operation; Structure and operations of TTL and CMOS gates; NAND in TTL, NAND and NOR in CMOS.

### **Text Books**

1. M. Morris Mano, Digital Logic and Computer Design, 4/e, Pearson Education, 2013
2. Thomas L Floyd, Digital Fundamentals, 10/e, Pearson Education, 2009.
3. D.V. Hall, "Digital Circuits and Systems", Tata McGraw Hill, 1989



4. R.P. Jain, “Modern digital Electronics”, Tata McGraw Hill, 4th edition, 2009

### Reference Books

5. M. Morris Mano, Michael D Ciletti , Digital Design With An Introduction to the Verilog HDL, 5/e, Pearson Education, 2013.
6. Donald D Givone, Digital Principles and Design, Tata McGraw Hill, 2003.
7. W.H. Gothmann, “Digital Electronics – An introduction to theory and practice”, PHI, 2nd edition ,2006
8. Wakerly J.F., “Digital Design: Principles and Practices,” Pearson India, 4th 2008
9. A. Ananthakumar, “Fundamentals of Digital Circuits”, Prentice Hall, 2nd edition, 2016
10. Fletcher, William I., An Engineering Approach to Digital Design, 1st Edition, Prentice Hall India, 1980

### COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                             | No of Lecture/Tutorial Hours |
|-----|-------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | Total Hours                                                                                                       | 36 Hours                     |
|     | <b>Module 1 (Number Systems)</b>                                                                                  | 7 hours                      |
| 1.1 | Decimal, Binary, Octal and Hexadecimal Number Systems- Number Base Conversions.                                   | 2 hour                       |
| 1.2 | Addition, Subtraction, Multiplication and Division of binary numbers.                                             | 1 hours                      |
| 1.3 | Addition and subtraction of BCD, Octal and Hexadecimal numbers.                                                   | 1 hours                      |
| 1.4 | Representation of negative numbers- Complements, Subtraction with complements.                                    | 2 hours                      |
| 1.5 | Binary coded decimal codes; Gray codes; Excess 3 code. Alphanumeric codes: ASCII.                                 | 1 hours                      |
|     | <b>Module 2 (Boolean Algebra and Karnaugh Maps)</b>                                                               | 8 hours                      |
| 2.1 | Postulates of Boolean Algebra. Basic theorems and Properties of Boolean Algebra. .                                | 2 hours                      |
| 2.2 | Minimization of Boolean expressions, Sum of Products (SOP), Product of Sums (POS) - Canonical and Standard forms. | 2 hours                      |



|     |                                                                                                                                                                                      |         |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| 2.3 | Simplification of Boolean Functions- Using Karnaugh- Map Method (upto five variables), Don't care conditions                                                                         | 2 hour  |
| 2.4 | Product of sums simplification, Tabulation Method.                                                                                                                                   | 2 hours |
|     | <b>Module 3 (Combinational Circuits)</b>                                                                                                                                             | 8 hours |
| 3.1 | Combinatorial Logic Systems - Binary adders and subtractors -Half adder, Full adder, Half Subtractor, Full Subtractor                                                                | 2 hours |
| 3.2 | Binary Parallel adder, Carry look ahead adder, BCD adder                                                                                                                             | 2 hours |
| 3.3 | Comparators – one bit and two bit, Multiplexers-Implementation of combinational circuits using Multiplexers                                                                          | 2 hours |
| 3.4 | Demultiplexers, Encoder, Decoder, Code converter-Binary to Gray, BCD to Excess 3.                                                                                                    | 2 hours |
|     | <b>Module 4 (Sequential Circuits)</b>                                                                                                                                                | 7 hours |
| 4.1 | Building blocks like S-R, JK and Master-Slave JK FF, Edge triggered FF, Conversion of Flipflops, Excitation table and characteristic equation.                                       | 3 hours |
| 4.2 | Shift registers-SIPO, SISO, PISO, PIPO., Shift Registers with parallel Load/Shift, Ring counter and Johnsons counter.                                                                | 2 hours |
| 4.3 | Asynchronous and Synchronous counter design                                                                                                                                          | 2 hours |
| 4.4 | Mod N counter, Up- down counter, BCD counter                                                                                                                                         | 2 hours |
|     | <b>Module 5 (TTL and CMOS)</b>                                                                                                                                                       | 6 hours |
| 5.1 | TTL, ECL, CMOS - Electrical characteristics of logic gates – logic levels and noise margins, fan-out, propagation delay, transition time, power consumption and power-delay product. | 2 hours |
| 5.2 | TTL inverter - circuit description and operation; CMOS inverter - circuit description and operation;                                                                                 | 2 hours |
| 5.3 | Structure and operations of TTL and CMOS gates; NAND in TTL, NAND and NOR in CMOS.                                                                                                   | 2 hours |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Perform the mentioned base conversions for the following numbers. (i) (563.8125)<sub>10</sub> to binary (ii) (78.89)<sub>10</sub> to octal (iii) (EC.4)<sub>16</sub> to decimal
2. Perform the following operations (i)E8AE<sub>16</sub>-C865<sub>16</sub> (ii) A4758-86348

#### Course Outcome 2 (CO 2):

1. Simplify the function  $F(A,B,C,D)=\Sigma(0,1,2,8,12,13,14)+d(3,5,10,15)$  using Karnaugh map.
2. Express  $F=(XY+Z)(Y+XZ)$  in both canonical forms.

**Course Outcome 3 (CO 3):**

1. Design a BCD to Excess-3 Code Convertor.
2. Implement the following using an 8x1 multiplexer  $F(A, B, C, D) = \Sigma m (0, 1, 3, 5, 6, 7, 8, 9, 11, 13, 14)$

**Course Outcome 4 (CO 4):**

1. Design a 4-bit binary asynchronous counter using JK flipflops. Give the state diagram and logic diagram.
2. With a circuit diagram, explain the working of master-slave JK flip-flop.

**Course Outcome 5 (CO 5):**

1. Define the terms noise margin, propagation delay and power dissipation of logic families. Compare TTL and CMOS logic families showing the values of above-mentioned terms.
2. Draw the circuit and explain the operation of a TTL NAND gate.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 2**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SECOND SEMESTER B.TECH DEGREE EXAMINATION, MAY2025**

**Course Code: B24EC1T03**

**Course Name: LOGIC CIRCUIT DESIGN**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks.**

1. Convert the hexadecimal number 2FC3 into binary and decimal.
2. The 2's complement representation of a binary number is 10101100. (i) Determine its decimal value. (ii) Represent it in 1's complement form.
3. Find the dual and complement of the boolean function  $F = AB' + B(A + B')$ .
4. Prove that  $x(x+y) = x$  using Boolean algebra postulates and rules.
5. Realize a one-bit comparator.
6. Explain the working of a decoder.
7. What is race around condition?
8. Write the excitation table and characteristic equation of SR flip-flop.
9. Define fan-in and fan-out of logic circuits.
10. Draw the circuit of a CMOS inverter and explain its working.

**PART B**

**Answer any one question from each module. Each question carries 14 marks.**

1. (a) Perform the subtraction  $43.5 - 67.25$  using 1) 2's complement 2) 1's complement 8

(b) Convert the following numbers to the base indicated:

- i.  $(1234)_8$  to base 10.
- ii.  $(23.875)_{10}$  to base 2.
- iii.  $(EC.5)_H$  to base 8 6

**OR**

2. (a) Solve the following binary arithmetic. 1)  $36.25 - 98.625$  (using 1's complement) 8  
2)  $53.5 - 29.25$  (using 2's complement)

(b) Perform the following operations (i)  $(520)_8 + (488)_8$  (ii)  $(520)_H - (488)_H$  6

3. (a) Minimize the following using K Map

- i.  $f = \sum m(1, 3, 4, 6, 8, 9, 11, 13, 15) + \sum d(0, 2, 14)$
- ii.  $f = \prod M(0, 2, 8, 9, 12, 13, 15)$
- iii.  $f = \sum m(0, 4, 5, 6, 8, 9, 10, 11, 16, 20, 22, 24, 25, 26, 27)$  12

(b) State and prove De Morgan's theorem. 2

**OR**

4. (a) Simplify the following Boolean function,  $f(A, B, C, D) = m(2, 6, 8, 9, 10, 11, 14, 15)$  using Quine-McCluskey tabular method. 10

(b) Prove that  $ABC + A' + AB'C = A' + C$  4

5. (a) Design a 4-bit BCD adder and draw the block diagram. 8

(b) Implement full adder using 8:1 Multiplexer. 6

**OR**

6. (a) Design a 4 bit Binary to Gray code converter. 10

(b) Implement half adder using decoder. 4

7. (a) Design a Mode 14 Synchronous UP counter using JKFlip-flop 10

(b) Explain the working of a 4 bit PISO register. 4

**OR**

8. (a) Design a Mod 7 Asynchronous UP counter with timing diagram 6

(b) Design Mod 8 Synchronous UP/DOWN counter using T Flip-flop. 8

9. (a) Explain in detail about TTL with open collector output configuration 7

(b) Draw an ECL basic gate and explain. 7

**OR**

10. (a) Describe the working of a 3 bit TTL NAND gate in totem pole configuration. 8

(b) Compare the characteristics features of TTL and ECL digital logic families. 6

| B24EC1T04 | ANALOG<br>CIRCUITS 1 | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|----------------------|---|---|---|---|--------|-------------------------|
|           |                      | 3 | 1 | 0 | 5 | 4      | 2024                    |

### Preamble

This course aims to equip

1. The students with an understanding of fundamental theory of electronic circuits using diodes and transistors.
2. Familiarization of data sheets, design of discrete electronic circuits and analyze the circuit performance.
3. Familiarize different circuit realization and application using diodes, BJT and FET transistors.

### Prerequisites

Nil

### Course Outcomes

After the completion of the course the student will be able to

|      |                                                                      |
|------|----------------------------------------------------------------------|
| CO 1 | Understand the different diodes, diode circuits and applications     |
| CO 2 | To study regulated power supplies                                    |
| CO 3 | Design transistor modelling and design amplifiers                    |
| CO 4 | Understand feedback in BJT amplifiers and improvement in performance |
| CO 5 | Study and analyse different sinusoidal oscillators                   |

### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 2    | 3    | 2    |      |      |      |      |      |      |       | 2     |
| CO 2 | 3    | 3    | 2    |      |      |      |      |      |      |       | 2     |
| CO 3 | 3    | 3    | 2    |      |      |      |      |      |      |       | 2     |
| CO 4 | 3    | 3    | 2    |      |      |      |      |      |      |       | 2     |
| CO 5 | 3    | 3    | 2    |      |      |      |      |      |      |       | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 15                    | 15                 | 30                                    |
| Understand       | 25                    | 25                 | 50                                    |
| Apply            | 10                    | 10                 | 20                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Quiz/Course Project         | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions carrying 3 marks each. Part B contains 2 questions from each module out of which 1 to be answered. Each question carries 14 mark and can have maximum 2 sub- divisions



## SYLLABUS

### MODULE 1

**Diode basics:** Semiconductor diode, Biasing, Diode current equation, Characteristics, Static and Dynamic resistance, Diode equivalent circuit.

**Wave shaping circuits:** Sinusoidal and non-sinusoidal wave shapes, Principle and working of RC differentiating and integrating circuits, Clipping circuits - Positive, negative and biased clipper. Clamping circuits - Positive, negative and biased clamper.

### MODULE 2

**Regulated power supplies:** Half wave and Full wave rectifiers: Centre tapped transformer and bridge circuits and waveforms. PIV of the diode, simple zener voltage regulator, series and shunt voltage regulator, 3 pin regulators-78XX and 79XX, block diagram and working of SMPS.

### MODULE 3

**Bipolar Junction Transistors (BJTs)** Basic construction and operation, Transistor configurations- Common Base, Common Emitter and Common Collector, Transistor currents and relation of  $I_E$  and  $I_C$ , Transistor amplifying action, detailed study of common emitter characteristics, Input- Output characteristics.

**BJT amplifiers:** DC biasing of BJT: Operating (Q) point, Load line analysis, Fixed Bias circuit, Emitter biased circuit, Voltage divider biased circuit. Bias stabilisation, Stability factor.

### MODULE 4

**Feedback Amplifiers:** Feedback connection types, Effect of Gain and bandwidth with feedback, hybrid II and T models of BJT,  $Z_i$ ,  $Z_o$ ,  $A_v$ ,  $A_i$  of different feedback amplifiers.

### MODULE 5

**Oscillators:** Classification, criterion for oscillation, RC phase shift oscillator, Wien bridge oscillator, Derivation of gain and frequency of oscillations. Tuned Oscillator circuits: Basics of resonant circuit oscillator, Colpitts and Hartley oscillators, Crystal oscillators: Series and parallel resonance of quartz crystal.

### Text Books

1. Robert Boylestad, Electronic Devices and Circuit Theory, Prentice Hall 7th Edition or latest
2. Thomas L Floyd, Electronic Devices, Pearson Education 7th Edition or latest .

### Reference Books

1. Integrated Electronics , Millman and Halkias, Mc Graw Hill Publications
2. Razavi B., “Fundamentals of Microelectronics”, Wiley, 2015
3. Neamen D., “Electronic Circuits, Analysis and Design”, 3/e, TMH, 2007

## COURSE CONTENTS AND LECTURE SCHEDULE

| No | Topic                                                                                                              | No of Lecture/Tutorial Hours |
|----|--------------------------------------------------------------------------------------------------------------------|------------------------------|
| 1  | Semiconductor diode, Biasing, Diode current equation                                                               | 1                            |
|    | Characteristics, Static and Dynamic resistance, Diode equivalent circuit                                           | 1                            |
|    | Sinusoidal and non-sinusoidal wave shapes.                                                                         | 1                            |
|    | Principle and working of RC differentiating and integrating circuits.                                              | 2                            |
|    | Clipping circuits - Positive, negative and biased clipper.                                                         | 2                            |
|    | Clamping circuits - Positive, negative and biased clamper.                                                         | 2                            |
| 2  | Half wave and Full wave rectifiers: Centre tapped transformer and bridge circuits and waveforms. PIV of the diode. | 3                            |
|    | Simple zener voltage regulator, series and shunt voltage regulator.                                                | 3                            |
|    | 3 pin regulators-78XX and 79XX, block diagram and working of SMPS.                                                 | 3                            |
| 3  | Basic construction and operation                                                                                   | 1                            |
|    | Transistor configurations- Common Base, Common Emitter and Common Collector                                        | 1                            |
|    | Transistor currents and relation of $\alpha$ and $\beta$ Transistor amplifying action.                             | 2                            |
|    | Detailed study of common emitter characteristics, Input-Output characteristics.                                    | 1                            |

|          |                                                                                                      |          |
|----------|------------------------------------------------------------------------------------------------------|----------|
|          | DC biasing of BJT: Operating (Q) point, Load line analysis,2.                                        | <b>2</b> |
|          | Fixed Bias circuit, Emitter biased circuit, Voltage divider biased circuit.                          | <b>1</b> |
|          | Bias stabilisation, Stability factor.                                                                | <b>1</b> |
| <b>4</b> | Feedback connection types.                                                                           | <b>3</b> |
|          | Effect of Gain and bandwidth with feedback.                                                          | <b>1</b> |
|          | Hybrid $\Pi$ and T models of BJT.                                                                    | <b>1</b> |
|          | $Z_i$ , $Z_o$ , $A_v$ , $A_i$ of different feedback amplifiers.4.                                    | <b>4</b> |
| <b>5</b> | Classification, criterion for oscillation.                                                           | <b>2</b> |
|          | RC phase shift oscillator, Wien bridge oscillator, Derivation of gain and frequency of oscillations. | <b>2</b> |
|          | Tuned Oscillator circuits: Basics of resonant circuit oscillator, Colpitts and Hartley oscillators.  | <b>3</b> |
|          | Crystal oscillators: Series and parallel resonance of quartz crystal.                                | <b>2</b> |

## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1):**

1. Analyse static and dynamic characteristics of pn junctions.
2. Describe the Forward bias and reverse bias in diodes.
3. Describe clipping and clamping using diodes.

### **Course Outcome 2 (CO 2):**

1. Compare the performance of Half wave and Full wave rectifiers.
2. Explain the working of SMPS.

### **Course Outcome 3 (CO 3):**

1. Explain the need of DC biasing of BJT and how operating (Q) point is fixed.
2. How Voltage divider biased circuit is designed in CE transistor circuit.
3. Describe BJT small signal ac analysis.

### **Course Outcome 4 (CO 4):**

1. Which are the different types of feedback amplifiers?
2. What is the effect of negative feedback in the gain and bandwidth of an amplifier?

### **Course Outcome 5 (CO 5):**

1. Explain the concept of Barkhausen criteria to convert the amplifier as an oscillator.
2. Derive the frequency of oscillations of RC phase shift and Wien bridge oscillator.
3. Describe the resonant circuit operation for Hartley and Colpitts oscillators.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

FIRST SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: B24EC1T04

ANALOG CIRCUITS 1

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks.**

1. Draw the dynamic and static resistance of a forward biased diode.
2. Design and draw a positive clipped diode circuit at 3 V level, given Sinewave input at 10 kHz  $10V_{pp}$ .
3. Derive the expression for PIV of the diode in half wave rectifier.
4. Draw and explain the block diagram of SMPS.
5. How the term “transistor” is formed from “transfer resistor” term.
6. Obtain the relation between  $\alpha$  and  $\beta$  in npn transistor.
7. Enumerate different feedback amplifiers.
8. Draw and explain hybrid Pi model of BJT.
9. Show that  $A\beta=1$  in a transistorized oscillator circuit.
10. Draw the circuit diagram of a Colpitts Oscillator.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

11. a. Design and draw the circuit diagram of a Clamper circuit with clamping levels at +5 V . Given a sinewave input at 1 kHz 5Vpp. Draw the input and output waveforms to scale. 7

- b. Design and draw the circuit diagram of a Trapezoidal clipper circuit with clipping levels at +3 V and -4V. Given a sinewave input at 1 kHz 12Vpp. Draw the input and output waveforms to scale. 7

OR

12. a. Write down the diode current equation and explain its components. Explain the dynamic and static resistance and represent them in V-I characteristics. 7  
b. Describe the operation of an RC integrated circuit. Derive the expression for the transfer function of the same. 7

13. a. Draw a simple Zener regulator circuit and explain its working. How Zener diode differs from conventional diodes in its operation. 7  
b. Design a Full wave rectifier circuit with a capacitor filter using a center tapped transformer with following specifications. Given  $V_{dc} = 12V$ , Ripple voltage  $< 100mV$ . Draw the circuit diagram and input output waveforms. 7

OR

14. a. With neat block diagram explain the working of SMPS. 7  
b. Design a half wave rectifier circuit with a capacitor filter using a center tapped transformer with following specifications. Given  $V_{dc} = 12V$ , Ripple voltage  $< 100mV$ . Draw the circuit diagram and input output waveforms. 7
15. a. Explain with necessary diagrams, the common base npn transistor configuration and show that output current is less than input current. 7  
b. Explain the term “Early effect” with the representation in V-I characteristics of a common emitter transistor configuration. 7

OR

16. a. Draw the basic constructional features of a npn transistor and explain the current components and its relations. 7  
b. Draw the V-I output characteristics of CE transistor configuration and explain the linear region of operation. 7
17. a. Derive the transfer function of a current series feedback amplifier. 7  
b. Derive the input and output impedances of current amplifier. 7

OR

18. a. Derive the transfer function of a voltage shunt feedback amplifier. 7  
b. Derive the input and output impedances of voltage amplifier. 7



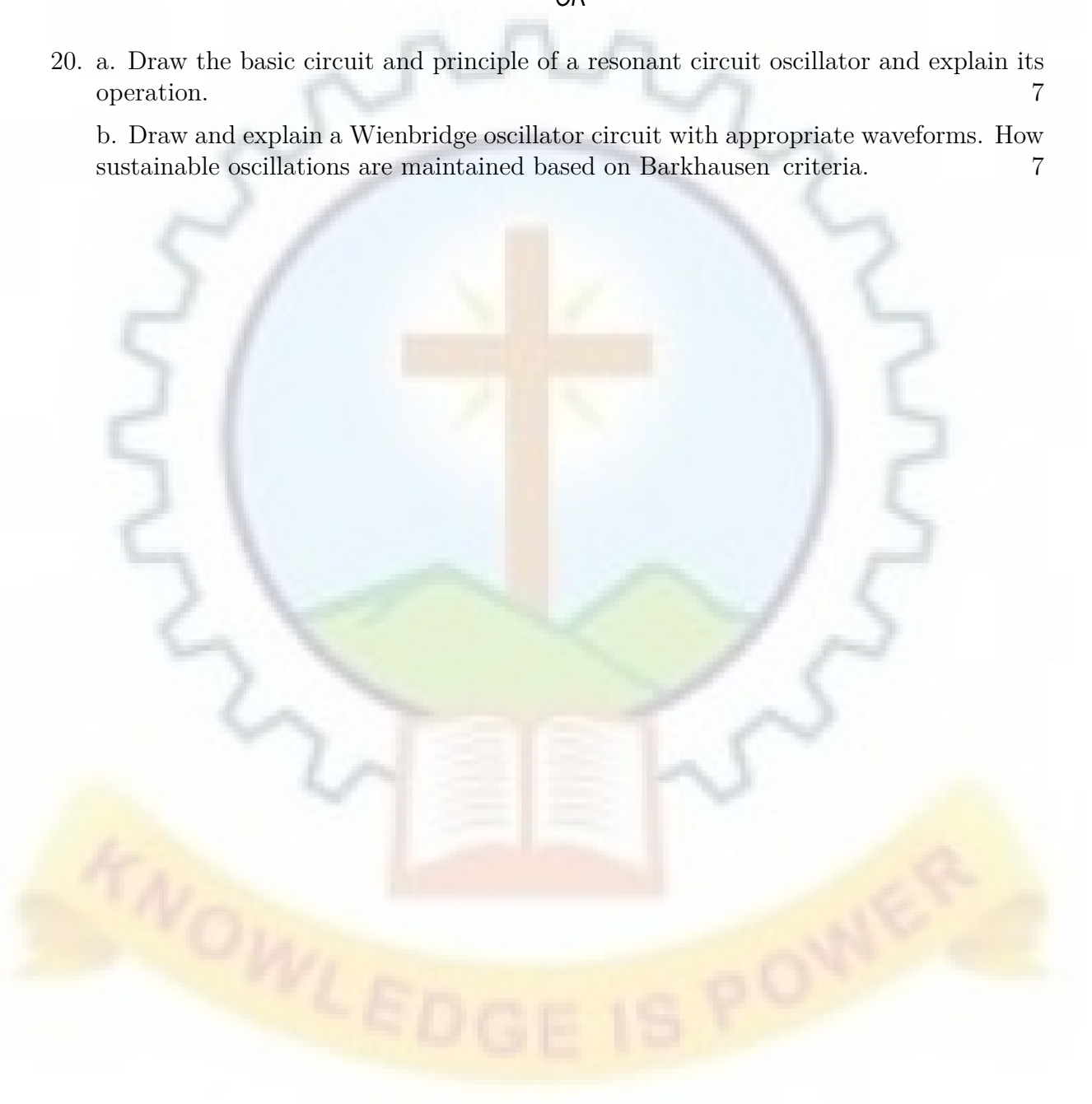
19. a. Describe the Barkhausen criteria in converting an amplifier to a sinusoidal oscillator. 7

b. Draw the circuit diagram of an RC phase shift oscillator and derive the expression for gain of the circuit. 7

OR

20. a. Draw the basic circuit and principle of a resonant circuit oscillator and explain its operation. 7

b. Draw and explain a Wienbridge oscillator circuit with appropriate waveforms. How sustainable oscillations are maintained based on Barkhausen criteria. 7



| B24EC1L01 | BASIC<br>ELECTRONICS<br>LAB | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|-----------------------------|---|---|---|---|--------|-------------------------|
|           |                             | 0 | 0 | 3 | 2 | 2      | 2024                    |

**Preamble**

The following experiments are designed to understand the basic building components of Electronics and evaluate and select appropriate device for various projects/product design.

**Prerequisite :** Nil

**Course Outcomes:** After the completion of the course the student will be able to

|      |                                                                                                                              |
|------|------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Make different wave shaping circuits and design DC power supplies ( <b>Apply, Analyze</b> ).                                 |
| CO 2 | Assess the location of Q point from V-I characteristics and predict the amplifier characteristics ( <b>Apply, Analyze</b> ). |
| CO 3 | Understand different amplifier configurations and analyze the gain parameters. ( <b>Apply, Analyze</b> ).                    |
| CO 4 | Assemble different sinusoidal oscillators suitable for various applications. ( <b>Apply, Analyze</b> ).                      |
| CO 5 | Evaluate the performance characteristics of FET devices and compare with BJT devices. ( <b>Apply, Analyze</b> ).             |

**Mapping of Course Outcomes With Program Outcomes**

|      | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| CO 1 | 3   | 3   | 3   | 2   | 2   | 0   | 0   | 3   | 1   | 0    | 3    |
| CO 2 | 3   | 3   | 3   | 2   | 2   | 0   | 0   | 3   | 1   | 0    | 2    |
| CO 3 | 3   | 3   | 3   | 1   | 2   | 0   | 0   | 3   | 1   | 0    | 2    |
| CO 4 | 3   | 3   | 3   | 1   | 2   | 0   | 0   | 3   | 1   | 0    | 2    |
| CO 5 | 3   | 3   | 3   | 2   | 2   | 0   | 0   | 3   | 1   | 0    | 2    |

**Mark Distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hour       |

**Continuous Internal Evaluation Pattern**

|                                   |          |
|-----------------------------------|----------|
| Attendance                        | 10 marks |
| Class Work/ Assessment /Viva-Voce | 20 marks |
| Viva-Voce/Test                    | 20 marks |

## SYLLABUS

### LIST OF EXPERIMENTS

(All experiments require appropriate design, development of circuit diagrams, plotting waveforms, graphs and necessary calculations wherever necessary)

|    |                                                                                                                                                        |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | Diode Experiments: Plotting forward bias, Finding dynamic and static resistance .                                                                      |
| 2  | Zener diode biasing: Plotting forward and reverse bias. Simple voltage regulator circuit and output plotting.                                          |
| 3  | Diode circuit applications: Wired gate, Clipping and Clamping circuits with fixed and variable voltage levels, Zener diode clippers                    |
| 4  | DC Power Supplies: Half wave and full wave rectifiers with and without capacitor filters,                                                              |
| 5  | Experiments on CE and CB npn transistor configurations. Determination of $\alpha$ and $\beta$                                                          |
| 6  | Common Emitter (npn) transistor characteristics, determination of Q point                                                                              |
| 7  | RRC Coupled amplifier, Design and implementation, Record of Frequency response, Determination of bandwidth. Transistor switch operation and waveforms. |
| 8  | Cascading of amplifiers, Product of gain                                                                                                               |
| 9  | Design and implementation of RC phase shift and Wien bridge oscillators                                                                                |
| 10 | Design and implementation of Hartley and Colpitts oscillators.                                                                                         |
| 11 | Determination of V-I characteristics JFET. Ohmic region and Active Linear regions, Determination of $g_m$                                              |

### Reference Books

1. Robert Boylestad, Electronic Devices and Circuit Theory, Prentice Hall 7th Edition or latest

| <b>B24EC1L02</b> | <b>SCIENTIFIC<br/>COMPUTING<br/>LAB</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF<br/>INTRODUCTION</b> |
|------------------|-----------------------------------------|----------|----------|----------|----------|---------------|---------------------------------|
|                  |                                         | 0        | 0        | 3        | 2        | 2             | 2024                            |

**Preamble**

The following experiments are designed to translate the mathematical concepts into system design. The students shall use Python for realization of experiments. Other softwares such as R/MATLAB/SCILAB/LabVIEW can also be used.

**Prerequisite**

Linear Algebra and Multi Variable Calculus

**Course Outcomes**

After the completion of the course the student will be able to

|             |                                                                                                                                                                                              |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Describe the needs and requirements of scientific computing and to familiarize one programming language for scientific computing and data visualization (Cognitive Knowledge Level : Apply). |
| <b>CO 2</b> | Approximate an array/matrix with matrix decomposition (Cognitive Knowledge Level : Apply).                                                                                                   |
| <b>CO 3</b> | Implement numerical integration and differentiation (Cognitive Knowledge Level : Apply).                                                                                                     |
| <b>CO 4</b> | Solve ordinary differential equations for engineering applications (Cognitive Knowledge Level : Apply).                                                                                      |
| <b>CO 5</b> | Simulate random processes and understand their statistics (Cognitive Knowledge Level : Apply).                                                                                               |

**Mapping of Course Outcomes With Program Outcomes**

|             | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> |
|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|
| <b>CO 1</b> | 3          | 3          | 3          | 2          | 3          |            |            | 3          | 1          |             | 3           |
| <b>CO 2</b> | 3          | 3          | 1          | 2          | 3          |            |            | 3          |            |             | 1           |
| <b>CO 3</b> | 3          | 3          | 1          | 1          | 3          |            |            |            |            |             | 1           |
| <b>CO 4</b> | 3          | 3          | 1          | 1          | 3          |            |            |            |            |             | 1           |
| <b>CO 5</b> | 3          | 3          | 2          | 2          | 3          |            |            | 3          | 1          |             | 1           |

## Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hour       |

## Continuous Internal Evaluation Pattern

|                                   |          |
|-----------------------------------|----------|
| Attendance                        | 10 marks |
| Class Work/ Assessment /Viva-Voce | 20 marks |
| Viva-Voce/Test                    | 20 marks |

## SYLLABUS

### LIST OF EXPERIMENTS

|    |                                                                                                                                                                                                                                                                                        |
|----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | Find the factorial of a given number and display the output.                                                                                                                                                                                                                           |
| 2  | Find the sum of n numbers and display the output.                                                                                                                                                                                                                                      |
| 3  | Display Fibinocci series.                                                                                                                                                                                                                                                              |
| 4  | Display the factors of a given number.                                                                                                                                                                                                                                                 |
| 5  | Input a row array and column array. Input a square matrix. Find the rank, inverse, transpose, determinant and eigen values of the matrix. Plot the real and imaginary values of eigen vectors.                                                                                         |
| 6  | Input a complex number in each quadrant. Find the absolute value, real and imaginary values, argument in degrees. Also perform arithmetic operations using complex numbers.                                                                                                            |
| 7  | Realize the functions sint, cost, sinht, cosht for the vector a. $t = [0, 10]$ with increment 0.01. b. $t = [-4\pi, 4\pi]$ with increment $0.01\pi$ Compute the first and second derivatives of these functions. Plot the first derivatives of the above functions in a single window. |
| 8  | Write a program to return the first and second derivative of the function $f(t) = 3t^4 + 5$ for the vector $t = [-3; 3]$ .                                                                                                                                                             |
| 9  | Write a program to return the value of an integral function                                                                                                                                                                                                                            |
| 10 | Write a program to return the value of an integral function using Trapezoidal and Simpson method.                                                                                                                                                                                      |
| 11 | Implement and plot the functions using stem plots, line plots, box plots, bar plots and scatter plots. Create legends in plots. $f(t) = \cos t$ $f(t) = \cos t \cos 5t + \cos 5t$                                                                                                      |
| 12 | Obtain the histogram of a given data and plot it.                                                                                                                                                                                                                                      |
| 13 | Simulate a coin toss that maps a head as 1 and tail as 0. Toss the coin $N = 100, 500, 1000$ and $5000$ times and compute the probability (p) of head in each case. Compute the absolute error in each case and plot against N and understand the law of large numbers.                |

|    |                                                                                                                                                                           |
|----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 14 | Create a uniform random vector with maximum magnitude 10, plot and observe. Set a threshold and Count how many times the function has gone above and below the threshold. |
| 15 | Write and execute a function to toss three fair coins simultaneously. Compute the probability of getting exactly two heads for 100 and 1000 number of tosses.             |
| 16 | Write a program to solve the first order and second order differential equation.                                                                                          |
| 17 | Two dice are rolled 50 times. Count the occurrence of 5 in both dice.                                                                                                     |
| 18 | Obtain the sum of the series $f = 1^2 + 2^2 + 3^2 + 4^2 + \dots$ such that the sum does not exceed 1000. The program should display how many terms are used in the sum.   |

### Reference Books

1. Holly Moore, MATLAB for Engineers, Pearson.
2. William Palm, MATLAB for Engineering Applications, McGraw Hill.



| B24MC1T03 | PROFESSIONAL COMMUNICATION AND ETHICS | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|---------------------------------------|---|---|---|---|--------|----------------------|
|           |                                       | 2 | 0 | 1 | 4 | P/F    | 2024                 |

### Preamble

This course aims to provide the students with the vital skills needed to excel in listening, reading, writing, and speaking. Whether conveying technical ideas or non-technical information, mastering these communication elements is crucial for aspiring professionals. The goal is to equip students with the ability to comprehend and successfully articulate ideas while also honing their persuasive communication skills. The course also aims to create in students awareness on ethics and human values.

### Prerequisite

Nil

### Course Outcomes

After the completion of the course the student will be able to

|      |                                                                                                                                                                                            |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Expand vocabulary and linguistic proficiency pertinent to the field of engineering (Cognitive Knowledge Level: Apply)                                                                      |
| CO 2 | Examine, comprehend, and succinctly describe a range of textual material. (Cognitive Knowledge Level: Apply)                                                                               |
| CO 3 | Produce clear, technically sound documents and presentations that follow all required conventions. (Cognitive Knowledge Level: Apply)                                                      |
| CO 4 | Manifest acute ethical awareness and effectively apply ethical principles in practical engineering scenarios. (Cognitive Knowledge Level: Apply)                                           |
| CO 5 | Analyze and address global ethical issues, showcasing an understanding of their roles as ethical leaders and contributors to technological development. (Cognitive Knowledge Level: Apply) |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 |      |      |      |      |      |      |      | 3    | 3    | 1     | 2     |
| CO 2 |      |      |      |      |      |      |      | 3    | 3    | 1     | 2     |
| CO 3 | 2    | 2    | 2    |      |      | 3    | 3    | 2    | 2    | 2     | 2     |
| CO 4 | 2    | 2    | 2    |      |      | 3    | 3    | 3    | 3    | 1     | 2     |
| CO 5 | 2    | 2    | 2    |      |      | 3    | 3    | 3    | 3    | 1     | 3     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|---------------------------------------|
|                  | Test<br>(% Marks)     |                                       |
| Remember         | 30                    | 30                                    |
| Understand       | 40                    | 40                                    |
| Apply            | 30                    | 30                                    |
| Analyse          |                       |                                       |
| Evaluate         |                       |                                       |
| Create           |                       |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks |
|-------------|-----------|-----------|
| 100         | 50        | 50        |

### Continuous Internal Evaluation Pattern

|                                                                  |          |
|------------------------------------------------------------------|----------|
| Attendance                                                       | 10 marks |
| Self Study (Regular assessment)                                  | 15 marks |
| Series test (one test, conducted for 50 marks and reduced to 25) | 25 marks |

### Regular assessment

|                                                                    |         |
|--------------------------------------------------------------------|---------|
| Project report presentation and technical presentation through PPT | 4 marks |
| Listening Test                                                     | 2 marks |
| Group discussion/mock job interview                                | 4 marks |
| Resume submission                                                  | 2 marks |
| Assignment/Case study                                              | 3 marks |

### End Semester Examination Pattern

Total Marks: 50, Time: 2 hours. There will be two parts; Part A and Part B. Part A contain 4 questions carrying 5 marks each. Part B contains one question from each module in two sets of which students should answer one from each set. Each question can have a maximum of 2 sub-divisions and carry 15 marks each.

## **SYLLABUS**

### **MODULE 1 (9 hours)**

#### **Communication Process**

Modes, Verbal and Non-Verbal Communication, Verbal Aptitude- Misspelled Words, synonyms, paraphrasing, sentence completion using appropriate words, subject-verb agreement, Reading-Strategies for Effective Reading, types, Listening-Active and Passive Listening, Barriers, Taking notes while listening Activity- Worksheets, Exercises, Synthesizing and deriving conclusions from technical articles videos, and podcasts

### **MODULE 2 (9 hours)**

#### **Professional discipline**

Public Speaking- Technical Talks- Formal and Informal Letters- Emails- Resume Preparation, Video Profile- GD Vs Debate-Dynamics of Professional Presentation (Individual and Group)- Format of Report, Proposal and Minutes.

Activity- Public Speaking, Podcast preparation, Resume preparation, Video profile creation, Company profiling, Group discussion, Technical Proposal, Structured Flow Analysis using AI.

### **MODULE 3 (9 hours)**

#### **Fundamentals of Ethical Engineering**

Introduction to Human Values - Morals, Ethics, and Integrity - Academic and Work Ethics - Service Learning and Civic Virtue - Respect, Peaceful Living, Caring, and Sharing - Values of Honesty, Courage, Cooperation, Commitment, Empathy, and Self-Confidence - Senses of Engineering Ethics - Moral Autonomy and Ethical Theories - Moral Issues and Dilemmas in Engineering.

### **MODULE 4 (9 hours)**

#### **Professional Responsibility in a Global Context**

Engineering as Social Experimentation - Responsible Experimentation and Codes of Ethics - Customs, Religion, and their Role in Engineering Ethics - Collegiality, Loyalty, and Conflict Management - Confidentiality, Conflicts of Interest, and Occupational Crime - Rights and Responsibilities in Engineering - Global Ethical Issues: Multinational Corporations, Environmental Ethics, Business Ethics, and Computer Ethics - Engineers as Leaders, Expert Witnesses, and Contributors to Technological Development.

### **Text Books**

1. Ashraf Rizvi, "Effective Technical Communication", 2<sup>nd</sup> Edition, McGraw Hill Education, 2017.
2. Meenakshi Raman and Sangeetha Sharma, "Technical Communication: Principles and Practice", 2<sup>nd</sup> Edition, Oxford University Press, 2011
3. M Govindarajan, S Natarajan and V S Senthil Kumar, Engineering Ethics, PHI Learning Private Ltd, New Delhi, 2012.
4. R S Naagarazan, A text book on professional ethics and human values, New age international (P) limited, New Delhi, 2006.

### **Reference Books**

5. English for Engineers and Technologists (Combined edition, Vol. 1 and 2), Orient Blackswan 2010.
6. Training in Interpersonal Skills: Tips for Managing People at Work, Pearson Education, India, 6<sup>th</sup> edition, 2015.
7. Mike W Martin and Roland Schinzinger, Ethics in Engineering, 4<sup>th</sup> edition, Tata McGraw Hill Publishing Company Pvt Ltd, New Delhi, 2014.
8. Charles D Fleddermann, Engineering Ethics, Pearson Education/ Prentice Hall of India, New Jersey, 2004.
9. Charles E Harris, Michael S Protchard and Michael J Rabins, Engineering Ethics- Concepts and cases, Wadsworth Thompson Learning, United states, 2005.

### **COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                         | <b>No of Lecture/Tutorial Hours</b> |
|-----------|----------------------------------------------------------------------|-------------------------------------|
|           | Total Hours                                                          | 36 Hours                            |
|           | <b>Module 1 (Communication Process)</b>                              | 9                                   |
| 1.1       | Modes, Verbal and Non-Verbal Communication,                          | 1                                   |
| 1.2       | Verbal Aptitude- Misspelled Words, synonyms, paraphrasing,           | 1                                   |
| 1.3       | Sentence completion using appropriate words, subject verb agreement, | 1                                   |
| 1.4       | Reading-Strategies for Effective Reading, types .                    | 1                                   |

|     |                                                                                                                                                      |   |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 1.5 | Listening-Active and Passive Listening, Barriers, Taking notes while listening.                                                                      | 1 |
| 1.6 | Activity- Public Speaking, Podcast preparation, Resume preparation, Video profile creation, Company profiling, Group discussion, Technical Proposal. | 4 |
|     | <b>Module 2 (Professional discipline)</b>                                                                                                            | 9 |
| 2.1 | Public Speaking- Technical Talks- Formal and Informal Letters                                                                                        | 1 |
| 2.2 | Emails- Resume Preparation, Video Profile, GD Vs Debate                                                                                              | 1 |
| 2.3 | Dynamics of Professional Presentation (Individual and Group).                                                                                        | 1 |
| 2.4 | Format of Report, Proposal and Minutes.                                                                                                              | 1 |
| 2.3 | Activity- Public Speaking, Podcast preparation, Resume preparation, Video profile creation, Company profiling, Group discussion, Technical Proposal. | 5 |
|     | <b>Module 3 (Fundamentals of Ethical Engineering)</b>                                                                                                | 9 |
| 3.1 | Introduction to Human Values - Morals, Ethics, and Integrity                                                                                         | 1 |
| 3.2 | Academic and Work Ethics - Service Learning and Civic Virtue - Respect, Peaceful Living, Caring, and Sharing.                                        | 2 |
| 3.3 | Values of Honesty, Courage, Cooperation, Commitment, Empathy, and Self-Confidence.                                                                   | 2 |
| 3.4 | Senses of Engineering Ethics - Moral Autonomy and Ethical Theories.                                                                                  | 2 |
| 3.5 | Moral Issues and Dilemmas in Engineering.                                                                                                            | 2 |
|     | <b>Module 4 (Professional Responsibility in a Global Context)</b>                                                                                    | 9 |
| 4.1 | Engineering as Social Experimentation - Responsible Experimentation and Codes of Ethics.                                                             | 1 |
| 4.2 | HCustoms, Religion, and their Role in Engineering Ethics - Collegiality, Loyalty, and Conflict Management                                            | 2 |
| 4.3 | Confidentiality, Conflicts of Interest, and Occupational Crime.                                                                                      | 1 |
| 4.4 | Rights and Responsibilities in Engineering - Global Ethical Issues.                                                                                  | 1 |
| 4.5 | Multinational Corporations, Environmental Ethics, Business Ethics, and Computer Ethics.                                                              | 2 |
| 4.6 | Multinational Corporations, Environmental Engineers as Leaders, Expert Witnesses, and Contributors to Technological Development.                     | 2 |



## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1):**

1. Analyze how different modes of communication impact the overall message.
2. Identify and use appropriate verbal communication skills in various contexts..
3. Identify different types of reading and apply suitable strategies accordingly
4. Recognize and overcome barriers to effective listening.

### **Course Outcome 2 (CO 2):**

1. Demonstrate confidence and competence in public speaking.
2. Compose well-structured written communications.
3. Participate effectively in group discussions and debates, showcasing critical thinking and communication skills.

### **Course Outcome 3 (CO 3):**

1. Understand the format and structure of professional reports and proposals.
2. Summarize and organize information effectively in meeting minutes.
3. Adapt presentation style based on the context and audience.

### **Course Outcome 4 (CO 4):**

1. Explain the role of professional ethics in technological development
2. Explain the need for environmental ethics in engineering projects
3. How civic virtue and integrity contribute to application of ethical principles

### **Course Outcome 5 (CO 5):**

1. Explain how ethical issues in the workplace affect the development of a company.
2. Show how occupational crimes are resolved by keeping the rights of employees
3. Explain the necessity of code of conduct for digital ethics



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 2**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SECOND SEMESTER B.TECH DEGREE EXAMINATION, JUNE 2025**

**Course Code: B24MC1T03**

**Course Name: PROFESSIONAL COMMUNICATION AND ETHICS**

Max. Marks: 50

Duration: 2 hours

**PART A**

**Answer all questions. Each question carries 5 marks.**

1. Find out which pair of words 'can be filled-up in the blanks in the sentence in the same sequence to make the sentence grammatically correct and meaningfully complete.
  - (a) He was ..... not to ..... done the exercise himself.  
a) expected, be b) required, being c) needed, get d) supposed, have
  - (b) A committee has been.....to.....the transformation of the city into an international finance center.  
a) Constituted, convert b) appointed, oversee c) inducted, change d) converged, evaluate
2. Highlight the differences between a group discussion (GD) and a debate.
3. Briefly explain morals, values, and ethics.
4. Provide an explanation on conflicts of interest with an example.

**PART B**

**Answer any one question from each set. Each question carries 15 marks.**

5. (a) "In today's world, being a good listener is more important than being a good Speaker." Enumerate (7)

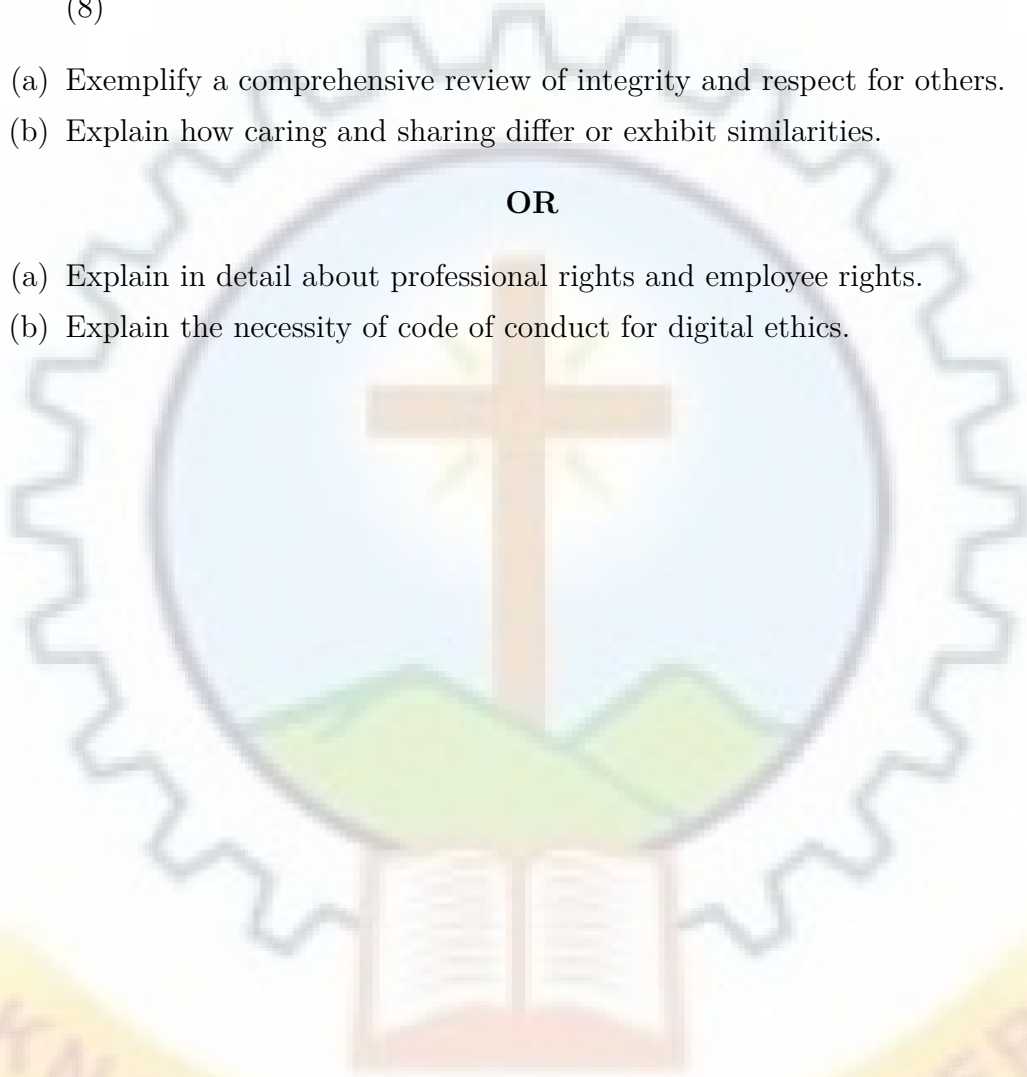
- (b) Help your friend by suggesting and explaining methods to improve his/her reading skills.. (8)

**OR**

6. (a) Compare and contrast the formats of a proposal and a report (7)  
(b) Discuss the challenges and benefits of delivering a presentation in a group setting (8)
7. (a) Exemplify a comprehensive review of integrity and respect for others. (8)  
(b) Explain how caring and sharing differ or exhibit similarities. (7)

**OR**

8. (a) Explain in detail about professional rights and employee rights. (8)  
(b) Explain the necessity of code of conduct for digital ethics. (7)



| B24MC1L02 | IDEA LAB | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|----------|---|---|---|---|--------|----------------------|
|           |          | 0 | 0 | 2 | 2 | P/F    | 2024                 |

### Preamble

This course enables the students to understand the concepts of design, development and documentation tools under various domains in engineering. The various topics covered in this course are concepts of 2D and 3D design, cutting, routing, engraving, milling, slicing, printing and fabrication. Students will be exposed to PCB design and populating. They will learn Microcontroller programming, embedded system design and technical documentation. This course helps students to analyse real-life problems and find solutions using multidisciplinary engineering.

### Prerequisite

Nil

### Course Outcomes

After the completion of the course the student will be able to

|      |                                                                                                                       |
|------|-----------------------------------------------------------------------------------------------------------------------|
| CO 1 | Create 2D and 3D models using appropriate tools. (Cognitive Knowledge Level : Analyse)                                |
| CO 2 | Design and fabricate circuits using PCB Design and fabrication mechanisms. (Cognitive Knowledge Level : Analyse)      |
| CO 3 | Develop project using appropriate Micro controller Programming. (Cognitive Knowledge Level : Apply)                   |
| CO 4 | Build a product for some applications using design and fabrication technologies. (Cognitive Knowledge Level : Create) |
| CO 5 | Create electronic documentation for the system/project using appropriate tools. (Cognitive Knowledge Level : Apply)   |

### Mapping of Course Outcomes With Program Outcomes Mark Distribution

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 2    | 1    | 3    |      | 2    |      |      | 1    | 1    |       |       |
| CO 2 | 1    |      | 1    |      | 1    |      |      |      |      | 1     | 1     |
| CO 3 | 2    | 2    | 2    | 2    | 2    | 1    | 1    | 2    | 2    | 2     | 2     |
| CO 4 | 1    | 2    | 3    | 2    | 3    | 3    | 3    | 3    | 3    | 3     | 3     |
| CO 5 |      |      |      |      |      | 1    |      |      | 3    |       |       |

| Total Marks | CIE Marks | ESE Marks (Internal) Micro Project |
|-------------|-----------|------------------------------------|
| 100         | 50        | 50                                 |

### Continuous Internal Evaluation Pattern

|                        |          |
|------------------------|----------|
| Attendance             | 10 marks |
| Class Work/ Assessment | 30 marks |
| Viva-Voce/ Test        | 10 marks |

### End Semester Evaluation Pattern:

|                             |          |
|-----------------------------|----------|
| Micro project Demonstration | 20 marks |
| Micro Project Presentation  | 20 marks |
| Micro Project Report        | 10 marks |

**Note:** The microproject has to be completed by the students as a group of a maximum of four students.

## SYLLABUS

### LIST OF EXPERIMENTS

Complete at least six experiments and one micro project from the given list.

|   |                                                                                                                                                                                                       |
|---|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Prepare a 2D and 3D model using any standard tool.                                                                                                                                                    |
| 2 | Use the 2D model to engrave and cut the acrylic sheet using laser cutter. Assemble the laser-cut parts to fabricate the final model.                                                                  |
| 3 | Use the 2D model for the fabrication of a model by using CNC milling.                                                                                                                                 |
| 4 | Use a 3D model to engrave the pattern using CNC milling on the acrylic/wood/-plastic block.                                                                                                           |
| 5 | Use the 3D design for the fabrication of a model by using a 3D printer. Use a slicing software and generate the corresponding G-codes.                                                                |
| 6 | Write a program to read the input port pins of a micro controller and write the same to the output pins. Use a development board.                                                                     |
| 7 | Write a program to read a sensor (temperature) and display it.                                                                                                                                        |
| 8 | Write a program in Arduino IDE for Arduino development board to design a temperature controller. Control the speed of a fan based on the room temperature. Display the temperature on an LCD display. |

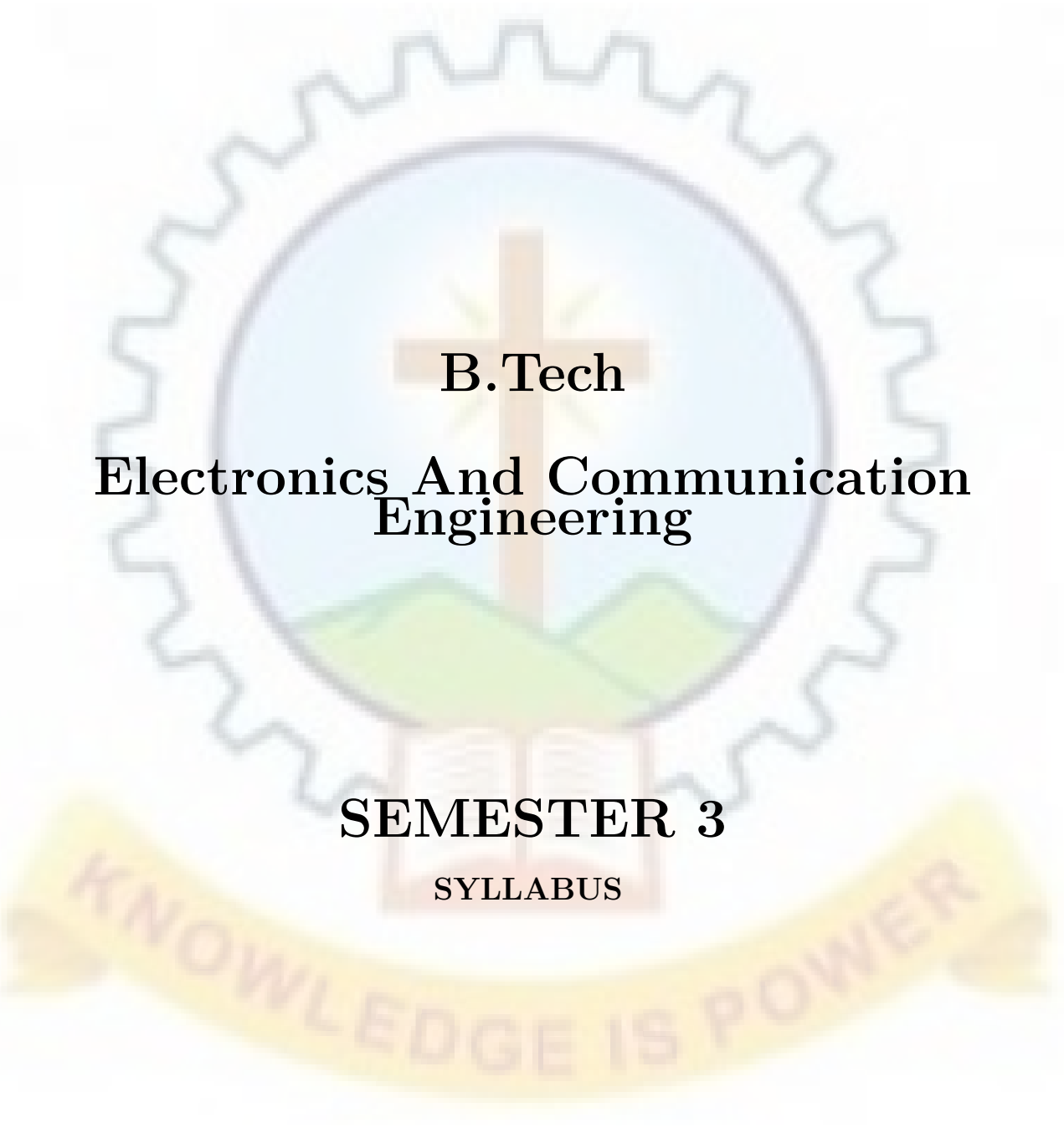
|    |                                                                                                                                                                   |
|----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 9  | Design a system to display the data send from the embedded system on a GUI in another Embedded system or PC (Wired – UART, I2C, SPI. Wireless – Bluetooth, Wifi ) |
| 10 | Complete a Microproject. Prepare a technical report using latex for the temperature controller system in the standard template of the university.                 |

## Reference Books

1. AICTE's Prescribed Textbook: Workshop / Manufacturing Practices (with Lab Manual), Khanna Book Publishing.
2. 3D Printing and Design, Dr. SabrieSoloman, ISBN: 978-9386173768, Khanna Book Publishing Company, New Delhi.
3. The Big Book of Maker Skills: Tools and Techniques for Building Great Tech Projects. Chris Hackett. Weldon Owen; 2018. ISBN-13: 978-1681884325.
4. The Total Inventors Manual (Popular Science): Transform Your Idea into a Top Selling Product. Sean Michael Ragan(Author).Weldon Owen;2017.ISBN-13:978-1681881584.
5. Make: Tools: How They Work and How to Use Them. Platt, Charles. Shroff/Maker Media. 2018. ISBN-13: 978- 352137374 .
6. The Art of Electronics. 3rd edition. Paul Horowitz and Winfield Hill. Cambridge University Press. ISBN: 9780521809269 .
7. Practical Electronics for Inventors. 4th edition. Paul Sherz and Simon Monk. McGraw Hill. ISBN-13: 978-1259587542 .
8. Encyclopedia of Electronic Components (Volume 1, 2 and 3). Charles Platt. Shroff Publishers. ISBN-13: 978-9352131945, 978-9352131952, 9789352133703.
9. Building Scientific Apparatus. 4th edition. John H. Moore, Christopher C. Davis, Michael A. Coplan and Sandra C. Greer. Cambridge University Press. ISBN-13: 978-0521878586.
10. Programming Arduino: Getting Started with Sketches. 2nd edition. Simon Monk. McGraw Hill. ISBN-13: 978-1259641633 .
11. Make Your Own PCBs with EAGLE: From Schematic Designs to Finished Boards. Simon Monk and Duncan Amos. McGraw Hill Education. ISBN-13: 978-1260019193.
12. Pro GIT. 2nd edition. Scott Chacon and Ben Straub. A press. ISBN-13: 9781484200773.
13. Venuvinod, PK., MA. W., Rapid Prototyping – Laser Based and Other Technologies, Kluwer.
14. Ian Gibson, David W Rosen, Brent Stucker., “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer,2010 .
15. Chapman W.A.J, “Workshop Technology”, Volume I, II, III, CBS Publishers and Distributors, 5th Edition, 2002.

# **MAR ATHANASIOUS COLLEGE OF ENGINEERING**

Government Aided, Autonomous Institution, Kothamangalam, Kerala,  
India

The logo of Mar Athanasius College of Engineering is a circular emblem with a gear-like outer border. Inside the circle, there is a blue upper half and a green lower half. A brown cross is centered in the blue area, with a yellow sunburst at its intersection. Below the cross, there are green hills. At the bottom of the emblem, there is a yellow banner with the text 'KNOWLEDGE IS POWER' in red capital letters.

## **B.Tech Electronics And Communication Engineering**

### **SEMESTER 3**

#### **SYLLABUS**



**SEMESTER 3**

| SLOT         | COURSE NO. | COURSES                                              | L-T-P-S | HOURS     | CREDIT    |
|--------------|------------|------------------------------------------------------|---------|-----------|-----------|
| A            | B24MA2T03A | Complex Variables and Applications of PDE            | 3-1-0-5 | 4         | 4         |
| B            | B24EC2T01  | Analog Circuits 2                                    | 3-1-0-5 | 4         | 4         |
| C            | B24EC2T02  | Computer Architecture and Microcontrollers           | 3-1-0-5 | 4         | 4         |
| D            | B24EC2T03  | Network Theory                                       | 2-1-0-4 | 3         | 3         |
| E            | B24HU2T01  | Business Economics and Financial Management          | 3-0-0-4 | 3         | 3         |
| G            | B24EC2L03  | Logic Circuit Design Lab                             | 0-0-3-2 | 3         | 2         |
| H            | B24EC2L04  | Electronic Circuits Lab                              | 0-0-3-2 | 3         | 2         |
| I            | B24MC2T04  | Universal Human Value and Constitutional Rights      | 2-0-0-2 | 2         | P/F       |
| J            | B24MC2T05  | Energy Conservation and Environmental Sustainability | 2-0-0-2 | 2         | P/F       |
| M            | B24ECM3X   | Minor                                                | 3-1-0-5 | 4         | 4         |
| <b>TOTAL</b> |            |                                                      |         | <b>32</b> | <b>22</b> |

**MINOR**

| COURSE NO | Courses                             |
|-----------|-------------------------------------|
| B24ECM31  | Electronic Circuits                 |
| B24ECM32  | Analog Communication                |
| B24ECM33  | Introduction To Signals And Systems |

| B24MA2T03A | COMPLEX<br>VARIABLES AND<br>APPLICATIONS<br>OF PDE | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|------------|----------------------------------------------------|---|---|---|---|--------|-------------------------|
|            |                                                    | 3 | 1 | 0 | 5 | 4      | 2024                    |

**Preamble**

This course introduces basic ideas of partial differential equations which are widely used in the modelling and analysis of a wide range of physical phenomena and has got application across all branches of engineering. To understand the basic theory of functions a complex variable residue integration and conformal transformation.

**Prerequisites**

A basic course in partial differentiation and complex numbers.

**Course Outcomes**

After completion of the course, the student will be able to:

|             |                                                                                                                                                |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Solve non linear and linear partial differential equations.<br>(Cognitive Knowledge Level: Apply)                                              |
| <b>CO 2</b> | Solve one-dimensional wave equation and heat equation using partial differential equations. (Cognitive Knowledge Level: Apply)                 |
| <b>CO 3</b> | Make use of Cauchy-Riemann equations to understand complex functions, its continuity and differentiability. (Cognitive Knowledge Level: Apply) |
| <b>CO 4</b> | Evaluate complex integrals using Cauchy's integral theorem and Cauchy's integral formula. (Cognitive Knowledge Level: Apply)                   |
| <b>CO 5</b> | Develop power series expansion of an analytic function.<br>(Cognitive Knowledge Level: Apply)                                                  |

### Mapping of Course Outcomes with Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 2    | 1    |      |      | 1    |      |      |      |      |       |       |
| CO 2 | 2    | 1    |      |      |      | 1    |      |      |      |       |       |
| CO 3 | 2    | 2    |      |      |      | 1    |      |      |      |       | 1     |
| CO 4 | 2    | 1    |      |      |      |      |      |      |      |       |       |
| CO 5 | 2    | 2    |      | 1    | 1    | 1    | 1    |      |      |       | 1     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                     | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|---------------------|---------------------------------------|
|                  | Test 1<br>(% Marks)   | Test 2<br>(% Marks) |                                       |
| Remember         | 20                    | 20                  | 20                                    |
| Understand       | 40                    | 40                  | 40                                    |
| Apply            | 40                    | 40                  | 40                                    |
| Analyse          |                       |                     |                                       |
| Evaluate         |                       |                     |                                       |
| Create           |                       |                     |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Quiz/Course project         | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contains 10 questions carrying 3 marks

each. Part B contains two questions from each module, out of which one is to be answered. Each question carries 14 marks and can have a maximum of two subdivisions.

## **SYLLABUS**

### **MODULE 1 (9 hours)**

#### **Partial Differential Equations**

Partial differential equations, formation of partial differential equations - elimination of arbitrary constants - elimination of arbitrary functions, solutions of a partial differential equations - equations solvable by direct integration, linear equations of the first order - Lagrange's linear equation, non-linear equations of the first order - Charpit's method, solution of equation by method of separation of variables.

(Text 1: Relevant topics from sections 17.1, 17.2, 17.3, 17.4, 17.5, 17.7, 18.1, 18.2)

### **MODULE 2 (9 hours)**

#### **Applications of Partial Differential Equations**

One-dimensional wave equation- vibrations of a stretched string, solution of the wave equation using the method of separation of variables, D'Alembert's solution of the wave equation. One-dimensional heat equation, solution of the heat equation.

(Text 1: Relevant topics from sections 18.3, 18.4, 18.5)

### **MODULE 3 (9 hours)**

#### **Complex Variable – Differentiation**

Complex function, limit, continuity, derivative, analytic functions, Cauchy-Riemann equations, harmonic functions, finding harmonic conjugate, conformal mappings – mappings  $w = z^2$ ,  $w = e^z$  linear fractional transformation  $w = \frac{1}{z}$ , fixed points.

(Text 2: Relevant topics from sections 13.3, 13.4, 17.1, 17.2)

### **MODULE 4 (9 hours)**

#### **Complex Variable - Integration**

Complex integration, line integrals in the complex plane, basic properties, first evaluation method - indefinite integration and substitution of limit, second evaluation method - use of

a representation of a path, contour integrals, Cauchy integral theorem on simply connected domain, Cauchy Integral formula.

(Text 2: Relevant topics from sections 14.1, 14.2, 14.3, 14.4)

## MODULE 5 (9 hours)

### Complex Variable - Residue Integration

Taylor's and Maclaurin series. Laurent's series (without proof), zeros of analytic functions, singularities, poles, removable singularities, essential singularities, and residues.

(Text 2: Relevant topics from sections 15.4, 16.1, 16.2, 16.3)

### Text Books

1. B. S. Grewal, *Higher Engineering Mathematics*, Khanna Publishers, 44th ed., 2018.
2. Erwin Kreyszig, *Advanced Engineering Mathematics*, John Wiley & Sons, 10th ed., 2016.

### Reference Books

1. Peter V. O'Neil, *Advanced Engineering Mathematics*, Cengage, 7th ed., 2012.

## COURSE CONTENTS AND LECTURE SCHEDULE

| No. | Topic                                                                                                                                                                                                                                         | No of Lecture/Tutorial Hours |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1: Partial Differential Equations</b>                                                                                                                                                                                               | <b>9</b>                     |
| 1.1 | Partial differential equations, Formation of partial differential equations – elimination of arbitrary constants - elimination of arbitrary functions, solutions of a partial differential equation, equations solvable by direct integration | 3                            |
| 1.2 | Linear equations of the first order - Lagrange's linear equation, non-linear equations of the first order - Charpit's method                                                                                                                  | 4                            |

|     |                                                                                                                                                                                           |                 |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 1.3 | Boundary value problems, method of separation of variables                                                                                                                                | 2               |
|     | <b>Module 2: Applications of Partial Differential Equations</b>                                                                                                                           | <b>9</b>        |
| 2.1 | One dimensional wave equation - vibration of a stretched string                                                                                                                           | 1               |
| 2.2 | Solution of wave equation using method of separation of variables, Fourier series solution of boundary value problems involving wave equation, D'Alembert's solution of the wave equation | 3               |
| 2.3 | One dimensional heat equation                                                                                                                                                             | 1               |
| 2.4 | Solution of the heat equation, using method of separation of variables, Fourier series solutions of boundary value problems involving heat equation                                       | 4               |
|     | <b>Module 3: Complex Variable – Differentiation</b>                                                                                                                                       | <b>9</b>        |
| 3.1 | Complex function, limit, continuity, derivative, analytic functions, Cauchy-Riemann equations                                                                                             | 4               |
| 3.2 | Harmonic functions, finding harmonic conjugate                                                                                                                                            | 2               |
| 3.3 | Conformal mappings - mappings of $w = z^2$ , $w = e^z$ , $w = 1/z$                                                                                                                        | 3               |
|     | <b>Module 4: Complex Variable – Integration</b>                                                                                                                                           | <b>9</b>        |
| 4.1 | Complex integration, line integrals in the complex plane, basic properties, first evaluation method, second evaluation method, use of representation of a path                            | 4               |
| 4.2 | Contour integrals, Cauchy integral theorem (without proof) on simply connected domain. Cauchy Integral formula (without proof)                                                            | 2               |
| 4.3 | Cauchy Integral formula                                                                                                                                                                   | 2               |
| 4.4 | Cauchy Integral formula for derivatives of an analytic function                                                                                                                           | 1               |
|     | <b>Module 5: Complex Variable – Residue Integration</b>                                                                                                                                   | <b>9</b>        |
| 5.1 | Taylor series and Maclaurin series                                                                                                                                                        | 2               |
| 5.2 | Laurent's series(without proof)                                                                                                                                                           | 3               |
| 5.3 | Zeros of analytic functions, singularities, poles, removable singularities, essential singularities                                                                                       | 2               |
| 5.4 | Residues                                                                                                                                                                                  | 2               |
|     | Total Hours                                                                                                                                                                               | <b>45 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1)

- Form the partial differential equation given  $z = f(x + it) + g(x - it)$ , where  $i = \sqrt{-1}$ .
- Solve  $\frac{\partial^2 z}{\partial y^2} = \sin(xy)$ .



3. Solve  $(y - z)p + (x - y)q = (z - x)$ .
4. Solve  $2zx - px^2 - 2qxy + pq = 0$ .
5. Solve  $\frac{\partial u}{\partial x} = 4\frac{\partial u}{\partial y}$  where  $u(0, y) = 8e^{-3y}$  by the method of separation of variables.

### Course Outcome 2 (CO 2)

1. Write all possible solutions of one-dimensional wave equation.
2. Find the steady state temperature distribution in a rod of length 10 cm with ends kept at  $20^\circ\text{C}$  and  $80^\circ\text{C}$ .
3. A string is stretched between the fixed points  $(0, 0)$  and  $(l, 0)$  and released at rest from the initial deflection given by  $f(x) = \begin{cases} \frac{2k}{l}x, & \text{when } 0 < x < \frac{l}{2} \\ \frac{2k}{l}(l - x), & \text{when } \frac{l}{2} < x < l \end{cases}$
4. A rod of length  $l$  with insulated sides is initially at a uniform temperature  $u_0$ . Its ends are suddenly cooled to  $0^\circ\text{C}$  and are kept at that temperature. Find the temperature function  $u(x, t)$ .

### Course Outcome 3 (CO 3)

1. Find the real and imaginary parts of the function  $5z^2 - 12z + 3 + 2i$ .
2. Check whether the function  $\frac{x+iy}{x^2+y^2}$  is analytic.
3. Determine the analytic function whose real part is  $e^{2x}(x \cos 2y - y \sin 2y)$ .
4. Find the fixed points of  $(a + ib)z^2$ .
5. Find the image of  $1 \leq |z| \leq 2$ ,  $\frac{\pi}{6} \leq \theta \leq \frac{\pi}{3}$  under the mapping  $w = z^2$ .

### Course Outcome 4 (CO 4)

1. Evaluate  $\int_0^{1+i} (x - iy) dz$  along the straight line path from 0 to  $1 + i$ .
2. Find the value of  $\int_C \frac{z^2+1}{z^2-1} dz$  where  $C$  is  $|z - 4 - 2i| = 6.5$ .
3. Evaluate  $\oint_C \frac{\sin z}{z+4iz} dz$  where  $C$  is  $|z| = 1$  in counter clockwise direction.
4. Integrate  $\oint_C \frac{\sinh 2z}{(z-\frac{1}{2})^4} dz$  in counterclockwise direction around the unit circle.

5. Evaluate  $\oint_C \frac{\cos \pi z^2 + \sin \pi z^2}{(z-1)(z-2)} dz$  where  $C$  is  $|z| = 3$  using Cauchy's integral formula.

**Course Outcome 5 (CO 5)**

1. Find the Maclaurin series expansion of  $\frac{z+2}{1-z^2}$ .
2. Find all singular points and residue of the function  $\operatorname{cosec} z$ .
3. Find the Laurents series of  $\frac{-2z+3}{z^2-3z+2}$  valid in (i)  $1 \leq |z| \leq 2$  (ii)  $|z| \geq 2$ .
4. Find the poles and residues of the function  $\frac{1}{z^4-1}$ .
5. Expand  $f(z) = \frac{z+1}{z-1}$  as a Taylor series about  $z = -1$ .



KNOWLEDGE IS POWER

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg.No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

THIRD SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: B24MA2T03A

Course Name: : COMPLEX VARIABLES AND APPLICATIONS OF PDE (CE,ME,EE,EC)

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Find the partial differential equation of all spheres of fixed radius having their centres in the xy-plane.
2. Solve  $\frac{\partial^2 z}{\partial x \partial y} = \frac{x}{y} + a$ .
3. Find the steady state temperature distribution in a rod of length 10 cm with ends are kept at  $20^\circ C$  and  $80^\circ C$ .
4. A tightly stretched elastic string of length  $l$  fixed at end points is initially at its rest position. If each of its points is displaced by giving a velocity, find its initial conditions and boundary conditions.
5. Test the continuity at  $z = 0$  of  $f(z) = \begin{cases} \frac{Re(z)}{1-|z|}, & z = 0 \\ 0, & z \neq 0 \end{cases}$
6. Show that an analytic function with constant real part is constant.
7. Evaluate  $\oint_{-\pi i}^{\pi i} \cos z \, dz$ .
8. Find the Maclaurin series of  $\frac{1}{1+z^2}$ .
9. Find the zeros and their order of the function  $f(z) = (1 - z^4)^2$ .
10. Find the residue at poles for the function  $f(z) = \frac{\sinh z}{z^4}$ .

**PART B**

**Answer any one question from each module. Each question carries 14 marks.**

11. (a) Form the partial differential equation by eliminating the arbitrary functions from  $z = yf(x) + xg(y)$ . (7 marks)
- (b) Solve  $(y + zx)p - (x + yz)q = x^2 - y^2$ . (7 marks)

**OR**

12. (a) Solve  $q + xp = p^2$ . (7 marks)
- (b) Using method of separation of variables, solve  $x^2 \frac{\partial u}{\partial x} + y^2 \frac{\partial u}{\partial y} = 0$ . (7 marks)

13. (a) A string is stretched between the fixed points  $(0, 0)$  and  $(l, 0)$  and released at rest from the initial deflection given by
- $$f(x) = \begin{cases} \frac{2k}{l}x, & \text{when } 0 < x < \frac{l}{2} \\ \frac{2k}{l}(l - x), & \text{when } \frac{l}{2} < x < l \end{cases} \quad (7 \text{ marks})$$
- (b) A rod of length  $l$  with insulated sides is initially at a uniform temperature  $u_0$ . Its ends are suddenly cooled to  $0^\circ\text{C}$  and are kept at that temperature. Find the temperature function  $u(x, t)$ . (7 marks)

**OR**

14. (a) A tightly stretched homogeneous string of length  $l$  with its fixed ends at  $x = 0$  and  $x = l$  executes transverse vibrations. Motion starts with zero initial velocity by displacing the string into the form  $f(x) = k(x - x^2)$ . Find the deflection  $u(x, t)$  at any time  $t$ . (7 marks)
- (b) Derive the solutions of one dimensional heat equation  $\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial x^2}$  using variable separable method. (7 marks)
15. (a) Check whether  $f(z) = iz\bar{z}$  is analytic. (7 marks)
- (b) Find the image of  $x > 1, y > 0$  under the transformation  $w = 1/z$ . (7 marks)

**OR**

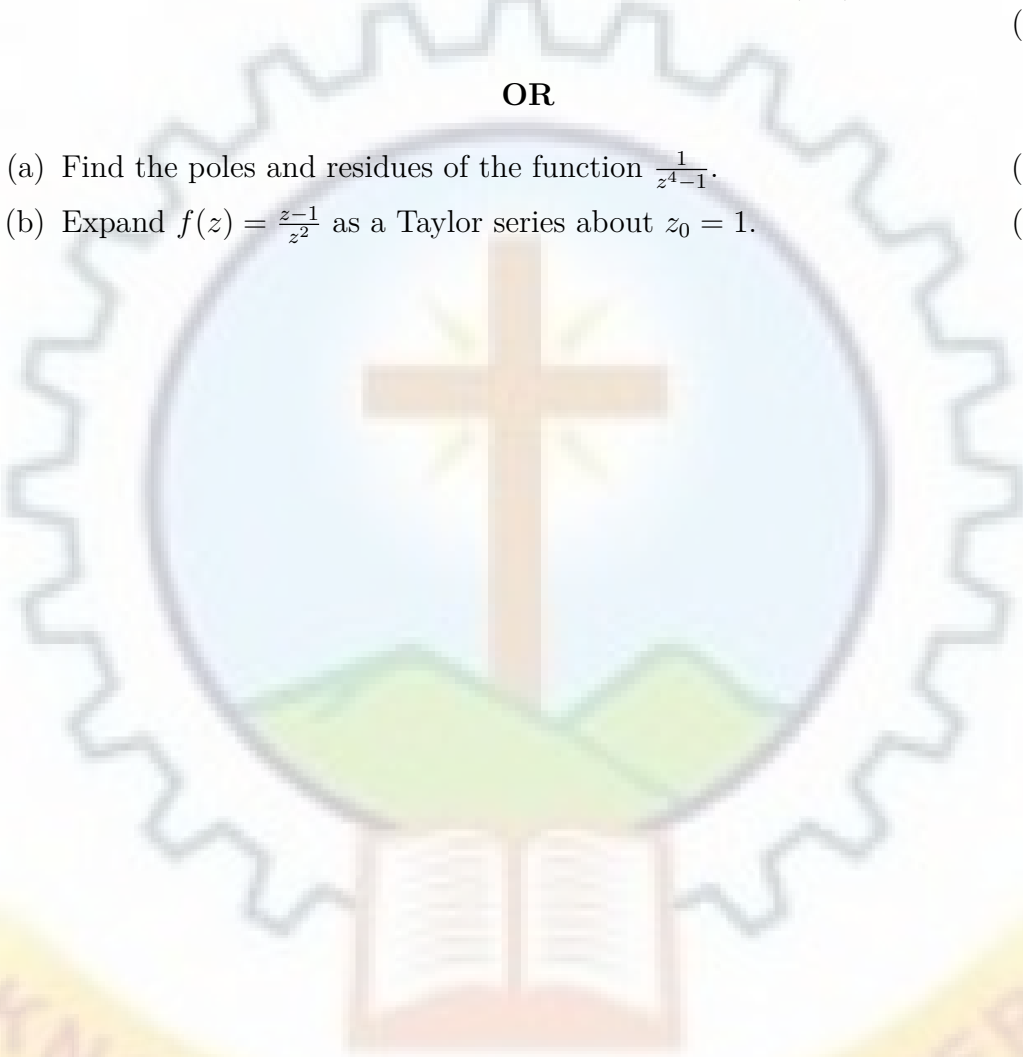
16. (a) Show that  $u = x^3 - 3xy^2 - 5y$  is harmonic. Also find the corresponding harmonic conjugate function. (7 marks)
- (b) Find the image of  $|z| \leq 2, \frac{\pi}{6} < \text{Arg} z < \frac{\pi}{3}$  under the mapping  $w = z^2$ . (7 marks)
17. (a) Evaluate  $\oint_C (z + \frac{1}{z}) dz$  where  $C$  is the unit circle traversed counterclockwise. (7 marks)
- (b) Evaluate  $\oint_C \frac{5z+7}{z^2+2z-3} dz$  where  $C$  is taken counterclockwise around the circle (i)  $|z - 2| = 2$  (ii)  $|z + i| = 1$ . (7 marks)

**OR**

18. (a) Integrate counterclockwise around the unit circle  $\oint_C \frac{\sin 2z}{z^4} dz$ . (7 marks)  
(b) Evaluate  $\int (z^2 + 3z) dz$  along the circle  $|z| = 2$  from  $(2, 0)$  to  $(0, 2)$  in counter clockwise direction. (7 marks)
19. (a) Expand  $f(z) = \frac{z}{(z+1)(z+2)}$  as a Laurent's series about  $z = -2$  in  $0 < |z + 2| < 1$ . (7 marks)  
(b) Determine and classify the singular points for  $f(z) = \frac{\sin z}{(z-\pi)^2}$  and  $g(z) = e^{\frac{-1}{z}}$ . (7 marks)

**OR**

20. (a) Find the poles and residues of the function  $\frac{1}{z^4-1}$ . (7 marks)  
(b) Expand  $f(z) = \frac{z-1}{z^2}$  as a Taylor series about  $z_0 = 1$ . (7 marks)



KNOWLEDGE IS POWER

| B24EC2T01 | ANALOG<br>CIRCUITS 2 | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|----------------------|---|---|---|---|--------|-------------------------|
|           |                      | 3 | 1 | 0 | 5 | 4      | 2024                    |

### Preamble

This course explores the core principles of MOSFET and BJT devices, from their construction and characteristics to advanced circuit applications. It covers MOSFET sub-circuits, biasing, single-stage and multi-stage amplifiers, and frequency response optimization. Differential amplifiers and BJT-based power amplifiers are examined for their design and performance. Students will learn to design and improve basic analog and power electronic circuits.

### Prerequisites

B24ESIT02: Basics of Electronics Engineering

B24ESIT04: Analog Circuits 1

### Course Outcomes

After the completion of the course the student will be able to :

|             |                                                                                                                                                                                                                                     |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Students will be able to explain the construction, types, and current-voltage characteristics of MOSFETs, including second-order effects like body effect and channel length modulation [Understand].                               |
| <b>CO 2</b> | Students will be able to design MOS sub-circuits such as current mirrors and active resistors, and apply biasing techniques like constant current source biasing to MOS amplifier circuits [Apply].                                 |
| <b>CO 3</b> | Students will be able to analyze the input impedance, output impedance, and gain of single-stage MOSFET amplifiers (common source, common drain, and common gate), along with their frequency response [Apply].                     |
| <b>CO 4</b> | Students will be able to describe the operation of MOS differential pairs and cascode amplifiers, including their DC and AC characteristics, and explain advantages like improved bandwidth and reduced Miller effect [Understand]. |
| <b>CO 5</b> | Students will be able to recall the operational principles and circuit configurations of BJT-based power amplifiers, including Class A, Class B, Class AB, Class C, and Class D [Remember].                                         |

### Mapping of Course Outcomes With Program Outcomes



|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 3    | 3    | 2    | 3    | 0    | 0    | 3    | 1    | 0     | 1     |
| <b>CO 2</b> | 3    | 3    | 3    | 2    | 3    | 0    | 0    | 3    | 1    | 0     | 1     |
| <b>CO 3</b> | 3    | 3    | 3    | 2    | 3    | 0    | 0    | 3    | 1    | 0     | 1     |
| <b>CO 4</b> | 3    | 3    | 3    | 2    | 3    | 0    | 0    | 3    | 1    | 0     | 1     |
| <b>CO 5</b> | 3    | 3    | 3    | 2    | 3    | 0    | 0    | 3    | 1    | 0     | 1     |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |        | End Semester Examination |
|------------------|-----------------------|--------|--------------------------|
|                  | Test 1                | Test 2 |                          |
| Remember         | 30                    | 30     | 30                       |
| Understand       | 40                    | 40     | 40                       |
| Apply            | 30                    | 30     | 30                       |
| Analyze          | 0                     | 0      | 0                        |

**Mark Distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

**Continuous Internal Evaluation Pattern**

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

**End Semester Examination Pattern**

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## **SYLLABUS**

### **MODULE 1**

**MOSFET basics:** : Construction, types, working, current-voltage characteristics.

**Second-order effects:** body effect, channel length modulation, sub-threshold conduction, low-frequency and high-frequency small-signal MOS model.

### **MODULE 2**

**MOS Sub-circuits:** MOS Switch, Active Resistor, Current Sinks and Sources. Current Mirrors: Simple Current Mirror.

**Biasing of MOS Amplifier Circuits** Biasing by Fixing  $V_{GS}$ , Biasing using Drain-to-Gate Feedback Resistor, Biasing using constant current source.

### **MODULE 3**

**MOS Single Stage Amplifiers:** Common source, Common drain amplifier as voltage follower, Common gate amplifier as a current follower (all with resistive and active loads, derivation of input impedance, output impedances and gain). Frequency response of the CS amplifier. Miller effect and bandwidth enhancement techniques. Frequency compensation in MOSFET amplifier circuits.

### **MODULE 4**

**Differential and Multi-stage Amplifiers** MOS Differential pair, operation with common-mode input voltage, operation with differential input voltage. DC Analysis - transfer characteristics, AC analysis - differential and common mode gains, CMRR. MOSFET Cascode Amplifier (CS-CG Configuration). Advantages over single-stage amplifiers (high gain, improved bandwidth, reduced Miller effect)

### **MODULE 5**

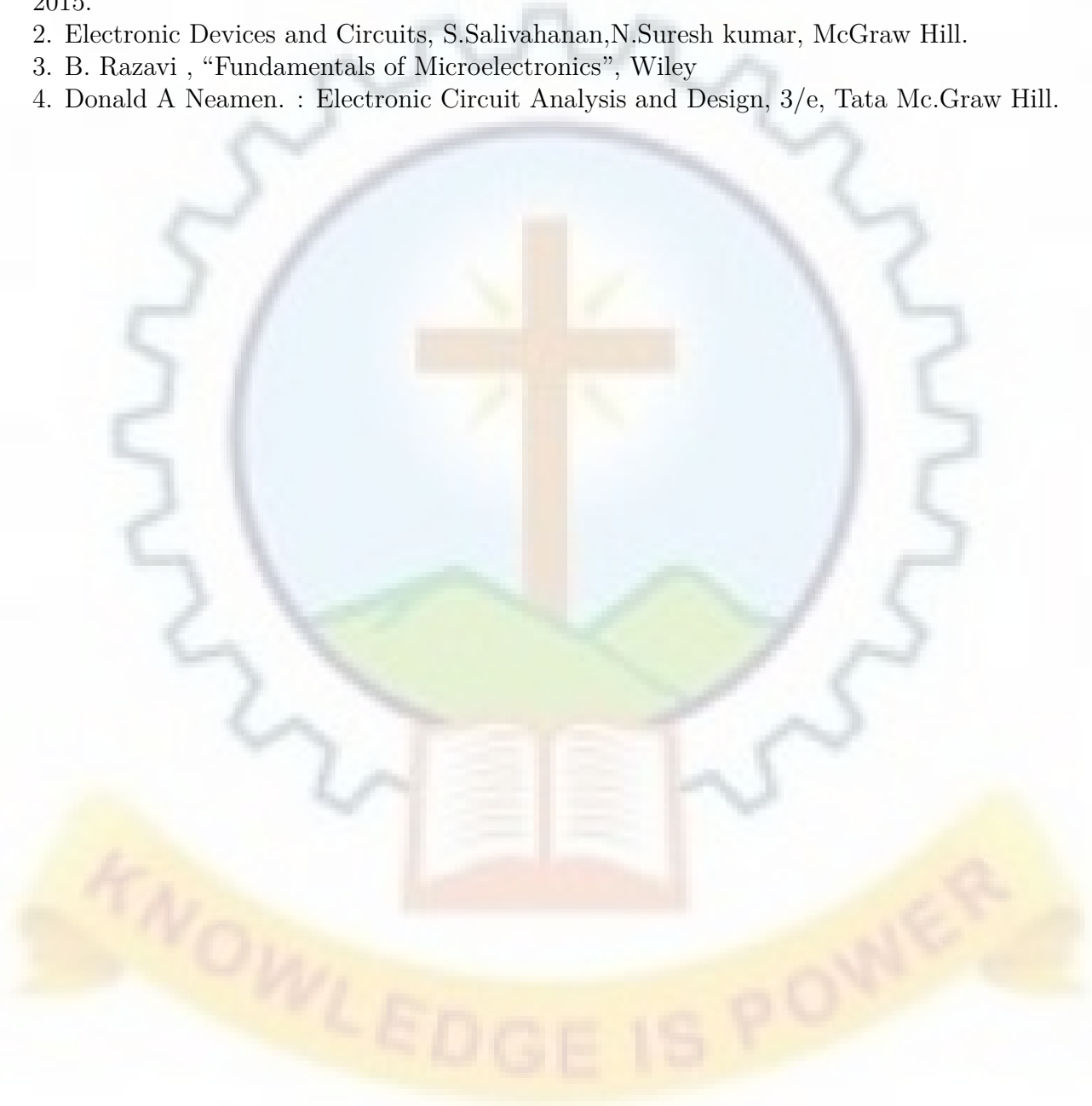
**Power Amplifiers using BJT:** Introduction, series-fed Class A amplifier, Transformer-Coupled Class A amplifier, Class B amplifier operation, Class B amplifier circuits, class AB power amplifier, distortion of amplifiers, Class C and Class D amplifier.

**Text Books**

1. Adel S. Sedra, Kenneth Carless Smith, Arun N. Chandorkar, Microelectronic circuits: theory and applications, Oxford University Press, New Delhi, 2009
2. J. B. Gupta, Electronic Devices and Circuits, Kataria, S. K., & Sons, 2010

**Reference Books**

1. Robert Boylestad and L Nashelsky, Electronic Devices and Circuit Theory, Pearson, 2015.
2. Electronic Devices and Circuits, S.Salivahanan,N.Suresh kumar, McGraw Hill.
3. B. Razavi , “Fundamentals of Microelectronics”, Wiley
4. Donald A Neamen. : Electronic Circuit Analysis and Design, 3/e, Tata Mc.Graw Hill.



## COURSE CONTENTS AND LECTURE SCHEDULE

| No         | Topic                                                                                                                                                        | No of Lecture/Tutorial Hours |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|            | <b>Module 1</b>                                                                                                                                              | <b>8</b>                     |
| <b>1.1</b> | <b>MOSFET basics:</b> Construction, types, working, characteristics.                                                                                         | <b>3</b>                     |
| <b>1.2</b> | <b>Second-order effects:</b> body effect, channel length modulation, sub-threshold conduction.                                                               | <b>2</b>                     |
| <b>1.3</b> | low-frequency and high-frequency small-signal MOS model.                                                                                                     | <b>3</b>                     |
|            | <b>Module 2</b>                                                                                                                                              | <b>8</b>                     |
| <b>2.1</b> | <b>MOS Sub-circuits:</b> MOS Switch, Active Resistor                                                                                                         | <b>2</b>                     |
| <b>2.2</b> | Current Sinks and Sources, Simple Current Mirror                                                                                                             | <b>3</b>                     |
| <b>2.3</b> | <b>Biasing of MOS Amplifier Circuits:</b> Biasing by Fixing $V_{GS}$ , Biasing using Drain-to-Gate Feedback Resistor, Biasing using constant current source. | <b>3</b>                     |
|            | <b>Module 3</b>                                                                                                                                              | <b>12</b>                    |
| <b>3.1</b> | Common Source amplifier with resistive, diode connected and current source loads.                                                                            | <b>3</b>                     |
| <b>3.2</b> | Common drain amplifier as a voltage follower.                                                                                                                | <b>3</b>                     |
| <b>3.3</b> | Common gate amplifier as a current follower (derivation of input impedance, output impedances and gain).                                                     | <b>3</b>                     |
| <b>3.4</b> | Frequency response of the CS amplifier. Miller effect and bandwidth enhancement techniques. Frequency compensation in MOSFET amplifier circuits.             | <b>3</b>                     |
|            | <b>Module 4</b>                                                                                                                                              | <b>10</b>                    |
| <b>4.1</b> | MOS Differential pair, operation with commonmode input voltage, operation with differential input voltage.                                                   | <b>2</b>                     |
| <b>4.2</b> | DC Analysis - transfer characteristics, AC analysis - differential and common mode gains, CMRR                                                               | <b>3</b>                     |
| <b>4.3</b> | MOSFET Cascode Amplifier (CS-CG Configuration).                                                                                                              | <b>3</b>                     |
| <b>4.4</b> | Advantages over single-stage amplifiers (high gain, improved bandwidth, reduced Miller effect)                                                               | <b>2</b>                     |
|            | <b>Module 5</b>                                                                                                                                              | <b>8</b>                     |
| <b>5.1</b> | Power Amplifiers using BJT: Introduction, series-fed Class A amplifier, Transformer-Coupled Class A amplifier.                                               | <b>3</b>                     |
| <b>5.2</b> | Class B amplifier operation, Class B amplifier circuits, class AB power amplifier, Amplifier distortion.                                                     | <b>3</b>                     |
| <b>5.3</b> | Class C and Class D amplifier.                                                                                                                               | <b>2</b>                     |
|            | <b>Total</b>                                                                                                                                                 | <b>46</b>                    |

## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1):**

1. Explain the VI characteristics of MOSFET
2. Explain the 2nd order effects in MOSFET

### **Course Outcome 2 (CO2):**

1. Explain the working of Simple Current Mirror.
2. Compare the operation of a MOS switch in triode and cutoff regions.

### **Course Outcome 3 (CO3):**

1. Explain the working principle of a Common Source (CS) amplifier with a resistive load. Derive the expression for voltage gain.
2. Evaluate the trade-offs between using a resistive load and an active load in a CS amplifier.

### **Course Outcome 4 (CO4):**

1. Derive the DC transfer characteristics of a MOSFET differential amplifier and discuss its significance.
2. Derive the common-mode gain of a MOS differential pair.

### **Course Outcome 5 (CO5):**

1. Differentiate between voltage and power amplifiers.
2. Explain the working of class AB power amplifier.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**THIRD SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2024**

**Course Code: B24EC2T01**

**COURSE NAME: ANALOG CIRCUITS 2**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**(Answer all questions. Each question carries 3 marks.)**

1. Explain the classification of MOSFET.
2. What is body effect
3. Explain the working of MOS resistor.
4. Explain the limitations of biasing a MOS amplifier by fixing  $V_{GS}$ .
5. Why is a Common Drain (CD) amplifier called a voltage follower? Explain its significance in impedance matching.
6. What is the Miller effect, and how does it affect the bandwidth of a CS amplifier?
7. What is CMRR?
8. What are the advantages of a cascode amplifier compared to a single-stage amplifier?
9. What is Crossover Distortion in power amplifiers?
10. What is a push-pull arrangement in power amplifiers?

**PART B**

**(Answer any one question from each module. Each question carries 14 marks)**



### **Module I**

11. a. With a neat diagram explain the working of n-channel enhancement MOSFET. (10 marks)  
b. What is channel length modulation? (4 marks)
12. a. With a neat diagram explain the working of p-channel enhancement MOSFET. (10 marks)  
b. What is sub-threshold conduction? (4 marks)

### **Module II**

13. a. Explain the working of a simple current mirror using MOSFETs. Derive the equation for the mirrored current and discuss its limitations. (10 marks)  
b. With a neat circuit diagram, explain MOS current sink. (4 marks)
14. a. Explain biasing using a constant current source in MOS amplifiers. Derive the expressions and discuss its advantages over other biasing methods. (8 marks)  
b. Compare different MOSFET biasing techniques in terms of stability, noise performance, and power efficiency. (6 marks)

### **Module III**

15. a. Derive the expression for voltage gain and output impedance of common drain amplifier. (10 marks)  
b. How does the resistive load differ from an active load in MOS amplifiers? (4 marks)
16. a. Explain the frequency response of a CS amplifier and derive the expressions for low-frequency and high-frequency cutoff points. (9 marks)  
b. Why is frequency compensation necessary in MOSFET amplifier circuits? (5 marks)

### **Module IV**

17. a. Derive the expression for voltage gain and output impedance of differential amplifier. (10 marks)  
b. Find out the input difference mode range of a differential amplifier. (4 marks)
18. a. Explain MOSFET cascode amplifier configuration. (7 marks)  
b. Explain the transfer characteristics of a MOS differential amplifier (7 marks)

### **Module V**

19. a. Explain the working principle of a series-fed Class A amplifier with a neat circuit diagram. Derive expressions for efficiency and power dissipation. (10 marks)  
b. How power amplifiers are classified (4 marks)
20. a. Explain the working of class AB power amplifier. (10 marks)  
b. What is cross over distortion? (4 marks)

| B24EC2T02 | COMPUTER<br>ARCHITECTURE<br>AND MICRO-<br>CONTROLLERS | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|-------------------------------------------------------|---|---|---|---|--------|-------------------------|
|           |                                                       | 3 | 1 | 0 | 5 |        |                         |

**Preamble:**

The 8051 microcontroller course provides students with a solid foundation in embedded system design through an in-depth exploration of 8051 architecture, programming, and interfacing techniques. By emphasizing the seamless integration of hardware and software, the course equips students with practical skills to develop real-world applications such as automation and control systems.

**Prerequisites:** B24EC1T03 : LOGIC CIRCUIT DESIGN

**Course Outcomes:**

After the completion of the course the student will be able to:

|             |                                                                                                                                                                                                                                        |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the Architecture and features of the 8051 Microcontroller. [Remember, Understand]                                                                                                                                           |
| <b>CO 2</b> | Understand and apply data transfer, arithmetic, logical, bit manipulation, and control transfer instructions, along with addressing modes, to write and debug simple assembly and C programs for embedded systems. [Understand, Apply] |
| <b>CO 3</b> | Configure timers, counters, and interrupts in the 8051 microcontroller for precise and efficient embedded system applications. [Understand, Apply]                                                                                     |
| <b>CO 4</b> | Understand and implement serial communication using UART in 8051, and effectively interface peripherals like LEDs, switches, 7-segment displays, ADC, DAC, LCD, and keypads for embedded system applications [Understand, Apply]       |
| <b>CO 5</b> | Interface advanced peripheral devices to 8051 microcontroller and design embedded system applications for real-world solutions. [Understand, Apply, Analyse]                                                                           |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    |      |      |      |      |      |      |      |      |       | 2     |
| <b>CO 2</b> | 3    | 2    | 2    | 1    | 2    |      |      |      |      |       | 2     |
| <b>CO 3</b> | 3    | 2    | 2    | 1    | 2    |      |      |      |      |       | 2     |
| <b>CO 4</b> | 3    | 3    | 3    | 3    | 3    | 2    |      | 2    |      |       | 3     |
| <b>CO 5</b> | 3    | 3    | 3    | 3    | 3    | 2    | 1    | 3    | 3    | 3     | 3     |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                     | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|---------------------|---------------------------------------|
|                  | Test 1<br>(% Marks)   | Test 2<br>(% Marks) |                                       |
| Remember         | 30                    | 30                  | 30                                    |
| Understand       | 50                    | 50                  | 50                                    |
| Apply            | 20                    | 20                  | 20                                    |
| Analyse          |                       |                     |                                       |
| Evaluate         |                       |                     |                                       |
| Create           |                       |                     |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Quiz/Course project         | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

#### Introduction to Microcontrollers and the 8051

Overview of Microcontrollers: Microcontrollers vs. Microprocessors, Applications of microcontrollers in embedded systems.

Introduction to 8051 Microcontroller: Features and specifications of the 8051 family, Internal architecture and block diagram of the 8051, Pin configuration and functions, Memory

organization: Program memory and data memory, Internal RAM and ROM, Stack and stack pointer.

## **MODULE 2**

### **8051 Instruction Set and Programming the microcontroller**

Instruction Set: Data transfer instructions, Arithmetic and logical instructions, Bit manipulation instructions, Control transfer (Branching) instructions.

Addressing Modes: Immediate, Direct, Register, Indirect and Indexed addressing modes.

Assembly Language Programming: Basics of assembly language, Writing and debugging simple programs, Example programs: Data transfer, Arithmetic operations, Logical operations.

C Programming: Learn the basics of C programming and explore advanced interfacing techniques for embedded system development.

## **MODULE 3**

### **Timers, Counters, and Interrupts**

Timers and Counters: Concept of timers and counters in 8051, Timer modes: Mode 0, Mode 1, Mode 2, Mode 3, Programming timers for delays and event counting.

Interrupts: Interrupt structure and vector table in 8051, Interrupt priorities, Programming external and internal interrupts, Applications of interrupts in embedded systems.

## **MODULE 4**

### **Serial Communication and Peripheral Interfacing**

Serial Communication: Basics of serial communication, UART and its configuration in 8051, Serial communication programming (mode selection, baud rate configuration).

Peripheral Interfacing: LED and switch interfacing, Interfacing 7-segment displays, Interfacing ADC (Analog to Digital Converter) and DAC (Digital to Analog Converter), LCD interfacing, keypad interfacing.

## **MODULE 5**

### **Applications and Real-World Projects**

Motor Control: Stepper motor interfacing, DC motor interfacing using H-bridge, Servo motor interfacing.

Embedded System Applications: Temperature monitor and control system.

## **Text Books**

1. Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay. "The 8051 Microcontroller and Embedded Systems Using Assembly and C", Printice Hall -Inc, Second, 2007.
2. Kenneth J Ayala, Dhananjay V Gadre, "8051 Microcontroller Architecture, Programming and Applications", Cengage Learning, 2010.

### Reference Books

1. Lyla B. Das, "Microprocessors and Microcontrollers", Pearson Education, 2011.
2. Datasheet, "8051 hardware Description", Intel Corporation, 1992.

### COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                               | No of Lecture/Tutorial Hours |
|-----|-----------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1 (Introduction to Microcontrollers and the 8051)</b>                                     | <b>8 hours</b>               |
| 1.1 | Microcontrollers vs. Microprocessors, Applications of microcontrollers in embedded systems          | 1 hour                       |
| 1.2 | Features and specifications of the 8051 family, Internal architecture and block diagram of the 8051 | 1 hour                       |
| 1.3 | Internal architecture and block diagram of the 8051                                                 | 1 hour                       |
| 1.4 | Pin configuration and functions                                                                     | 1 hour                       |
| 1.5 | Memory organization: Program memory and data memory                                                 | 1 hour                       |
| 1.6 | Internal RAM                                                                                        | 1 hour                       |
| 1.7 | Internal ROM                                                                                        | 1 hour                       |
| 1.8 | Stack and stack pointer                                                                             | 1 hour                       |
|     | <b>Module 2 (8051 Instruction Set and Programming)</b>                                              | <b>10 hours</b>              |
| 2.1 | Data transfer instructions,                                                                         | 1 hour                       |
| 2.2 | Arithmetic instructions                                                                             | 1 hour                       |
| 2.3 | Logical instructions                                                                                | 1 hour                       |
| 2.4 | Bit manipulation instructions, Control transfer (Branching) instructions                            | 1 hour                       |
| 2.5 | Addressing Modes: Immediate, Direct addressing modes, Register addressing mode                      | 1 hour                       |
| 2.6 | Indirect and Indexed addressing modes                                                               | 1 hour                       |
| 2.7 | Memory organization – RAM and ROM                                                                   | 1 hour                       |
| 2.8 | Basics of assembly language, Writing and debugging simple programs                                  | 1 hour                       |



|      |                                                                                                   |                 |
|------|---------------------------------------------------------------------------------------------------|-----------------|
| 2.9  | Basics of C Programming, Writing and debugging simple programs                                    | 1 hour          |
| 2.10 | Example programs: Data transfer, Arithmetic operations, Logical operations and device interfaces. | 1 hour          |
|      | <b>Module 3 (Timers, Counters, and Interrupts)</b>                                                | <b>10 hours</b> |
| 3.1  | Concept of timers and counters in 8051, Associated registers and configurations                   | 2 hour          |
| 3.2  | Timer modes: Mode 0, Mode 1, Mode 2, Mode 3                                                       | 2 hour          |
| 3.3  | Programming timers for delays and event counting                                                  | 1 hour          |
| 3.4  | Interrupt structure and vector table in 8051                                                      | 1 hour          |
| 3.5  | Interrupt priorities                                                                              | 1 hour          |
| 3.6  | Programming external and internal interrupts                                                      | 2 hour          |
| 3.7  | Applications of interrupts in embedded systems                                                    | 1 hour          |
|      | <b>Module 4 (Serial Communication and Peripheral Interfacing)</b>                                 | <b>9 hours</b>  |
| 4.1  | Basics of serial communication                                                                    | 1 hour          |
| 4.2  | UART and its configuration in 8051                                                                | 1 hours         |
| 4.3  | Serial communication programming (mode selection, baud rate configuration)                        | 1 hours         |
| 4.4  | LED and switch interfacing                                                                        | 1 hours         |
| 4.5  | Interfacing 7-segment displays - Multiplexing modes                                               | 1 hours         |
| 4.6  | Interfacing ADC (Analog to Digital Converter)                                                     | 1 hours         |
| 4.7  | Interfacing DAC (Digital to Analog Converter)                                                     | 1 hours         |
| 4.8  | LCD interfacing                                                                                   | 1 hour          |
| 4.9  | Keypad interfacing                                                                                | 1 hour          |
|      | <b>Module 5 (Applications and Real-World Projects)</b>                                            | <b>8 hours</b>  |
| 5.1  | Stepper motor interfacing                                                                         | 2 hour          |
| 5.2  | DC motor interfacing using H-bridge                                                               | 2 hour          |
| 5.3  | Servo motor interfacing                                                                           | 1 hour          |
| 5.4  | Embedded System Applications - general considerations                                             | 1 hour          |
| 5.5  | Temperature monitor and control system                                                            | 2 hour          |
|      | <b>Total Hours</b>                                                                                | <b>45 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. How a microcontroller is different from a microprocessor?
2. What are the peripherals available in 8051 microcontroller?
3. Explain the multiplexing of port pins in 8051 uC.

#### Course Outcome 2 (CO 2):



1. How the RAM area of 8051 uC is divided?
2. What is the use of bit addressable area in the 8051?
3. What is the maximum size of internal RAM, External data memory and external code memory in 8051 uC?

**Course Outcome 3 (CO 3):**

1. Write an ALP to find the biggest in a block of data of 10bytes stored in internal RAM locations starting from 30H and send it to port P1.
2. Write an embedded C program to sort the content of memory locations 10H to 20H in descending order.
3. Write an ALP to multiply the numbers stored in two consecutive memory locations and store the result in the consecutive memory locations.

**Course Outcome 4 (CO 4):**

1. Draw a circuit to show how an LED and a switch to control the LED are connected to the 8051 uC. Write an ALP to control the LED using the switch.
2. Draw a circuit to show how a relay is connected to the port pin of 8051 uC.
3. Draw a circuit to show how a temperature sensor is connected to the 8051 uC.

**Course Outcome 5 (CO 5):**

1. Draw an interface of a temperature sensor and a fan to the 8051 uC. Write an ALP to control the room temperature.
2. Draw an interface of a photo transistor and an LED light to the 8051 uC. Write an ALP to control the light intensity in the room.
3. Draw an interface of an RFID reader and a digital door lock to the 8051 uC. Write an ALP to control the door lock by using an RFID tag.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 2**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**THIRD SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2025**

**Course Code: B24EC2T02**

**Course Name: COMPUTER ARCHITECTURE AND MICROCONTROLLERS**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks.**

1. What is the size of the RAM in 8051?
2. Define address bus, data bus and control bus.
3. Draw and explain the PSW of 8051 microcontroller.
4. Write the functions of the following instructions. a) ANL A,@R1 b)RLC A c)MOVX A,@R0
5. What is a constant in embedded C?
6. Write an ALP to copy a block of 8 bytes of data from the RAM location 20H to another location with address 80H.
7. What is the difference between a timer and a counter?
8. Explain the format of the SCON special function register.
9. The 8051 microcontroller typically uses a crystal frequency of 11.0592 MHz. Why?
10. What are the predefined interrupt priorities in the 8051 microcontroller, and how can they be modified?

**PART B**

**Answer any one question from each module. Each question carries 14 marks.**

1. (a) Draw and explain the architecture of the 8051 microcontroller. (8 Marks)
- (b) How does a computer execute instructions stored in its memory? (6 Marks)

**OR**

2. (a) What are the rotate and shift instructions in the 8051 microcontroller used for? (5 Marks)
  - (b) How is the RAM of the 8051 microcontroller divided? (9 Marks)
3. (a) Differentiate the branching instructions SJMP, AJMP and LJMP in the 8051 microcontroller. (8 Marks)
  - (b) Write an ALP to transfer 10 data bytes stored at locations starting from 21H to another location in RAM starting from 51H. Find the second largest value in the data. (6 Marks)

**OR**

4. (a) Write an ALP to sort an array of 10 bytes stored in the memory location starting from 20H. (9 Marks)
  - (b) Explain the addressing modes of 8051 with examples (5 Marks)
5. (a) Explain the TCON and TMOD special function registers of 8051 microcontroller. (8 Marks)
  - (b) Write an ALP to generate a square wave of frequency 100kHz on pin P1.0 using timer 1 operating in mode 0. Assume a crystal frequency 11.0592 MHz. (6 Marks)

**OR**

6. (a) Illustrate the interface diagram showing the connection of the 8051 microcontroller to the DAC8080 via port P1. Additionally, write a program to generate a ramp signal. (9 Marks)
  - (b) Write a C program to read the port P1. Compare the value with 100. If it is less than 100, send it to port P0; if it is greater than 100, send it to port P2. (5 Marks)
7. (a) What is the maximum delay that can be generated using an 8051 timer in Mode 1 with a 12 MHz crystal oscillator? Show the calculations. (9 Marks)
  - (b) Write an ALP to generate a sine wave of frequency 100kHz on pin P1.0 using timer 1 operating in mode 0. Assume a crystal frequency of 12MHz. (5 Marks)

**OR**

8. (a) Write an embedded C program for the 8051 uC to send a letter 'A' serially with a baud rate of 9600 continuously. (8 Marks)

- (b) Draw the circuit diagram to show interface between 8051 uC and 16x2 LCD module. Write an embedded C program to send the message "Hello world" to the LCD. (6 Marks)

9. (a) Draw the circuit diagram to show the interface between the 8051 uC and ADC chip. Write an embedded C program to read an analog value from the potentiometer. (9 Marks)
- (b) Draw the circuit diagram to show the interface between 8051 uC and the 4x4 keypad. Display the key pressed on an LCD. Design the interface and write an embedded C program for the implementation. (5 Marks)

**OR**

10. (a) Draw the circuit diagram to show the interface between the 8051 uC and a DC motor. Write an embedded C program to rotate the motor clockwise. (8 Marks)
- (b) Explain interfacing of the stepper motor with the 8051 uC. Write a C program to continuously rotate the motor in a clockwise direction in full step mode. (6 Marks)

| B24EC2T03 | NETWORK THEORY | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|----------------|---|---|---|---|--------|----------------------|
|           |                | 2 | 1 | 0 | 4 |        |                      |

### Preamble

This course aims to equip students with the knowledge and skills to analyze circuit networks, focusing on a clear understanding of basic circuit elements and transforms.

### Prerequisites

B24EC1T02 : Electrical Circuit Theory

B24ES1T02 : Basics of Electrical & Electronics Engineering.

### Course Outcomes

After the completion of the course, the student will be able to:

|      |                                                                                                                                     |
|------|-------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Utilize fundamental concepts and circuit laws to effectively solve simple AC and DC electric circuits.[Remember, Understand, Apply] |
| CO 2 | Develop and solve AC and DC circuits using circuit analysis and network theorems [Remember, Understand]                             |
| CO 3 | Apply Laplace transform to solve networks and determine the transient behaviour of RL,RC and RLC networks. [Understand, Apply]      |
| CO 4 | Apply Network functions to analyse the single port and two port networks. [Understand, Apply]                                       |
| CO 5 | Understand and examine the two port network parameters.[Remember, Understand]                                                       |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    | 3    | 2    |      | 1    |      |      |      |       | 3     |
| CO 2 | 3    | 2    | 3    | 2    |      | 1    |      |      |      |       | 3     |
| CO 3 | 3    | 2    | 3    | 2    |      | 1    |      |      |      |       | 3     |
| CO 4 | 3    | 2    | 3    | 2    |      | 1    |      |      |      |       | 3     |
| CO 5 | 3    | 2    | 3    | 2    |      | 1    |      |      |      |       | 3     |
| CO 6 | 3    | 2    | 3    | 2    |      | 1    |      |      |      |       | 3     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 30                    | 30                 | 30                                    |
| Understand       | 30                    | 30                 | 30                                    |
| Apply            | 40                    | 40                 | 40                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                         |          |
|-----------------------------------------|----------|
| Attendance                              | 10 marks |
| Continuous Assessment Test (2 numbers)  | 25 marks |
| Assignment/Class work/Tutorial Problems | 10 marks |
| Self Study                              | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.



## SYLLABUS

### MODULE 1

**Fundamental Concepts of Circuit Theory:** Introduction to mesh and node analysis, Mesh and node analysis of AC and DC networks containing independent and dependent sources (Review and Problems). Supermesh and Supernode analysis. .

**Resonance :** Series resonance, Parallel resonance (bandwidth, Q factor and Selectivity), include simple problems on Q factor and bandwidth.

### MODULE 2

**Network Theorems :** Thevenin's theorem, Norton's theorem, Superposition theorem, Reciprocity theorem, Maximum power transfer theorem. (Applied to both dc and ac circuits having independent and dependent sources). .

### MODULE 3

**Application of Laplace Transforms :** Laplace Transforms and Inverse Laplace Transforms, Initial value theorem and Final value theorem, Transformation of basic signals and circuits into s-domain.

**Transformed Impedance:** Analysis of networks with transformed impedance and dependent sources. Transient analysis of RL, RC, and RLC networks (using time-domain and Laplace transform techniques) with impulse, step and sinusoidal inputs (with and without initial conditions).

### MODULE 4

**Network functions:** Network functions for the single port and two port network. Properties of driving point and transfer functions. Problems to find driving point and transfer functions. Network functions, Significance of poles and zeros, Pole-zero plot from network functions.

### MODULE 5

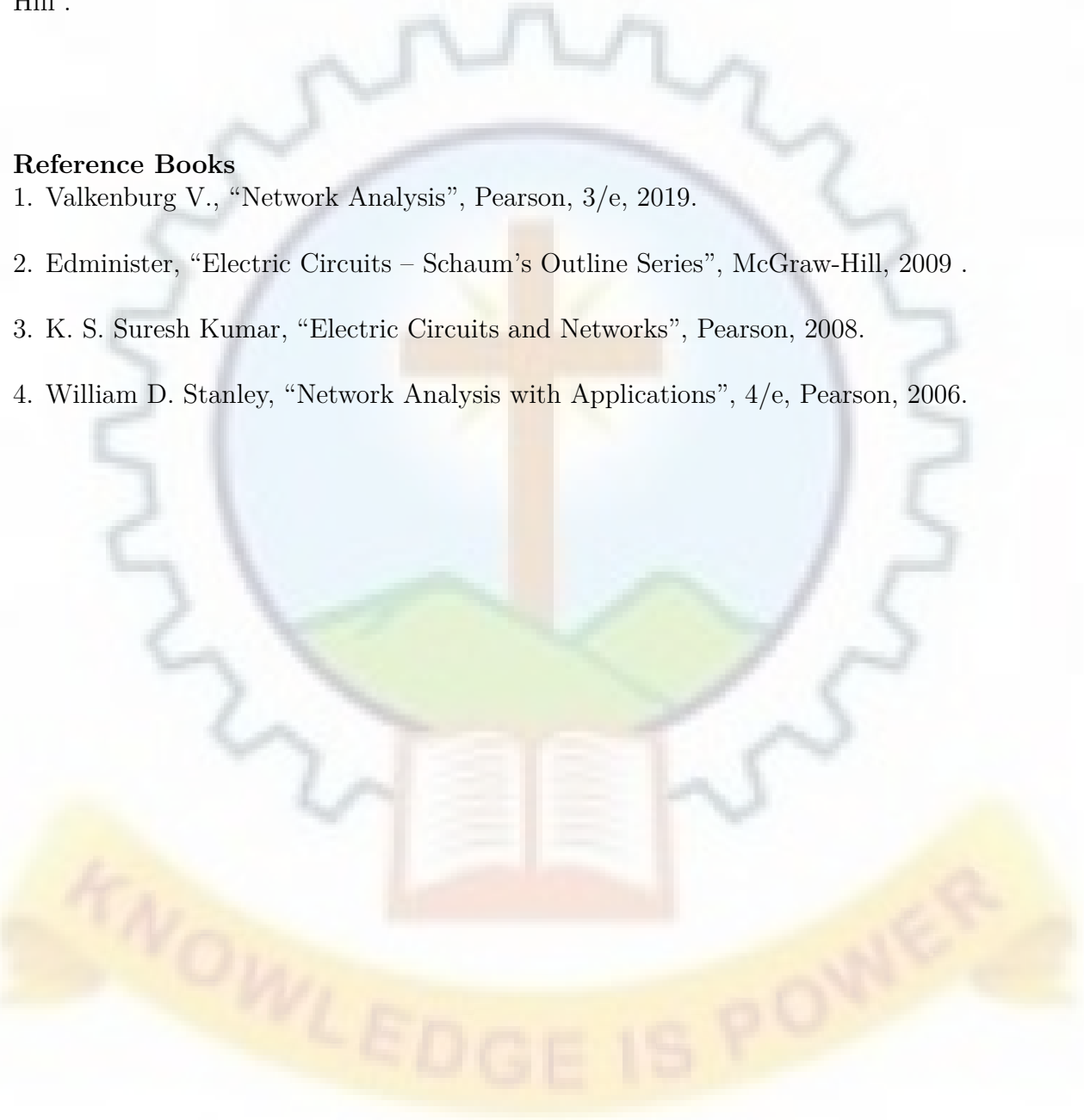
**Two port network Parameters :** Impedance, Admittance, Transmission and Hybrid parameters of two port network, properties of parameters: reciprocity and symmetry, Problems on DC and simple problems on AC circuits. Series and parallel connections of two port networks.

**Text Books**

1. Ravish R., “Network Analysis and Synthesis”, 2/e, McGraw-Hill, 2015.
2. Sudhakar A, Shyammohan S. P., “Circuits and Networks- Analysis and Synthesis”, McGraw Hill, 5/e, 2015 .
3. W. Hayt, J. Kemmerly, J. Phillips, S. Durbin, “Engineering Circuit Analysis,” McGraw Hill .

**Reference Books**

1. Valkenburg V., “Network Analysis”, Pearson, 3/e, 2019.
2. Edminister, “Electric Circuits – Schaum’s Outline Series”, McGraw-Hill, 2009 .
3. K. S. Suresh Kumar, “Electric Circuits and Networks”, Pearson, 2008.
4. William D. Stanley, “Network Analysis with Applications”, 4/e, Pearson, 2006.



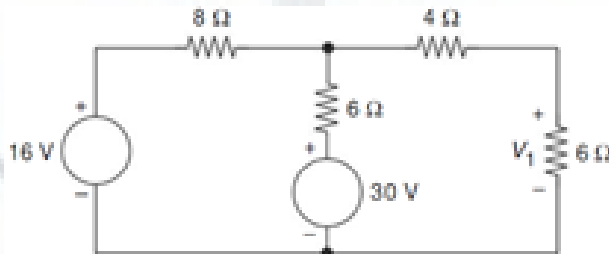
## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                                              | No of Lecture/Tutorial Hours |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                                                    | <b>6</b>                     |
| 1.1 | Introduction to mesh and node analysis                                                                                                                                             | 1                            |
| 1.2 | Mesh and node analysis of AC and DC networks containing independent and dependent sources (Review and Problems                                                                     | 3                            |
| 1.3 | Series resonance, Parallel resonance (bandwidth, Q factor and Selectivity)                                                                                                         | 1                            |
| 1.4 | Simple problems on Q factor and bandwidth.                                                                                                                                         | 1                            |
|     | <b>Module 2</b>                                                                                                                                                                    | <b>7</b>                     |
| 2.1 | Thevenin's theorem, Norton's theorem                                                                                                                                               | 2                            |
| 2.2 | Superposition theorem                                                                                                                                                              | 2                            |
| 2.3 | Reciprocity theorem                                                                                                                                                                | 1                            |
| 2.4 | Maximum power transfer theorem. (Applied to both dc and ac circuits having independent and dependent sources                                                                       | 2                            |
|     | <b>Module 3</b>                                                                                                                                                                    | <b>9</b>                     |
| 3.1 | Laplace Transforms and Inverse Laplace Trans- forms                                                                                                                                | 1                            |
| 3.2 | Initial value theorem and Final value theorem                                                                                                                                      | 1                            |
| 3.3 | Transformation of basic signals and circuits into s-domain                                                                                                                         | 2                            |
| 3.4 | Analysis of networks with transformed impedance and dependent sources                                                                                                              | 1                            |
| 3.5 | Transient analysis of RL, RC, and RLC networks (using time-domain and Laplace transform techniques) with impulse, step and sinusoidal inputs (with and without initial conditions) | 4                            |
|     | <b>Module 4</b>                                                                                                                                                                    | <b>6</b>                     |
| 4.1 | Network functions for the single port and two port network. Properties of driving point and transfer functions                                                                     | 2                            |
| 4.2 | Problems to find driving point and transfer functions                                                                                                                              | 2                            |
| 4.3 | Network functions, Significance of poles and zeros                                                                                                                                 | 1                            |
| 4.4 | Pole-zero plot from network functions.                                                                                                                                             | 1                            |
|     | <b>Module 5</b>                                                                                                                                                                    | <b>8</b>                     |
| 5.1 | Impedance, Admittance, Transmission and Hybrid parameters of two port network                                                                                                      | 3                            |
| 5.2 | Properties of parameters: reciprocity and symmetry                                                                                                                                 | 1                            |
| 5.3 | Problems on DC and simple problems on AC circuits                                                                                                                                  | 2                            |
| 5.4 | Series and parallel connections of two port networks.                                                                                                                              | 2                            |
|     | <b>Total Hours</b>                                                                                                                                                                 | <b>36 Hours</b>              |

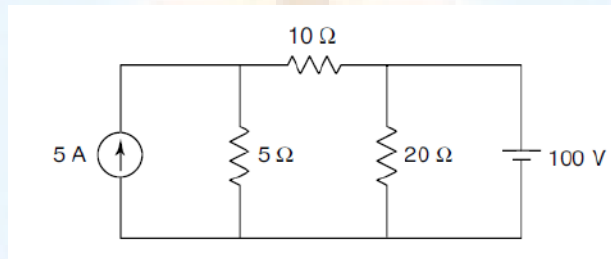
## CO ASSESSMENT QUESTIONS

### Course Outcome 1 (CO 1):

1. Find the voltage  $V_1$  across the 6 ohm resistance using (i) the nodal analysis and (ii) the mesh analysis.

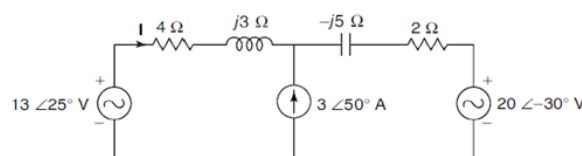


2. Determine the values for the three mesh currents

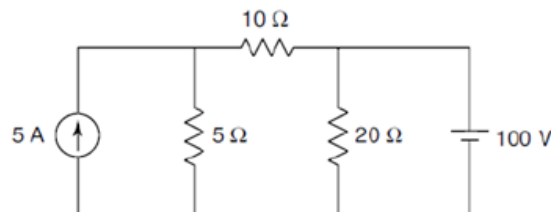


### Course Outcome 2 (CO 2):

1. Find the current  $I$  in the network using superposition theorem



2. Find the current through the 20 Ω resistor using Thevenin's theorem.

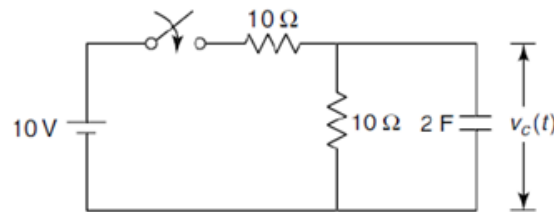


### Course Outcome 3 (CO 3):

1. Find the inverse Laplace transform of

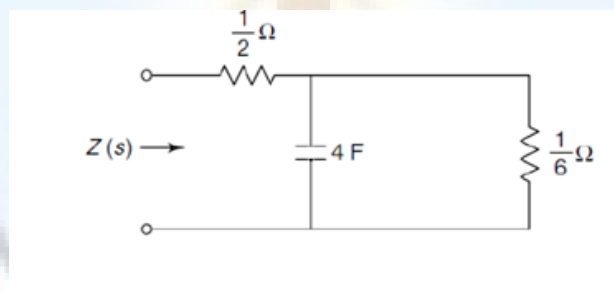
$$\frac{(S + 2)}{S^2(S + 3)}$$

2. The switch in the network is closed at  $t = 0$ . Determine the voltage across the capacitor.

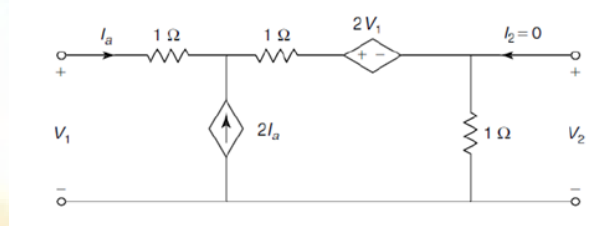


#### Course Outcome 4 (CO 4):

1. Determine the poles and zeros of the impedance function  $Z(s)$

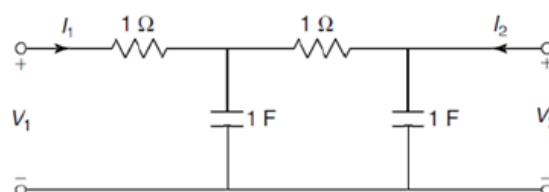


2. Find the voltage transfer function  $V_2/V_1$  for the network.

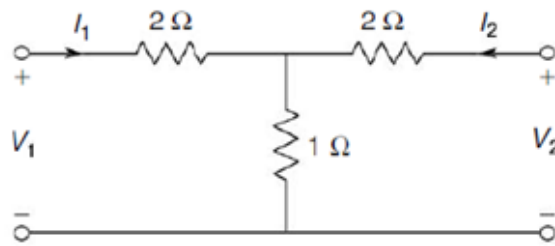


#### Course Outcome 5 (CO 5):

1. Obtain the admittance parameters for the network.



2. Two identical network sections are connected in series. Obtain the Z-parameters of the overall connection.





MODEL QUESTION PAPER

QP CODE:

Pages: 5

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

THIRD SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: B24EC2T03

Course Name: NETWORK THEORY

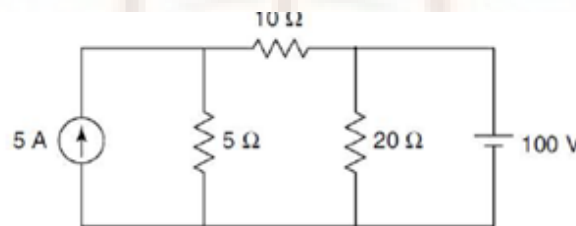
Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks

1. Differentiate between mesh analysis and node analysis.
2. Explain the concept of super-mesh with the help of a suitable example.
3. State maximum power transfer theorem.
4. Find the current through  $20\ \Omega$  resistor using superposition theorem.

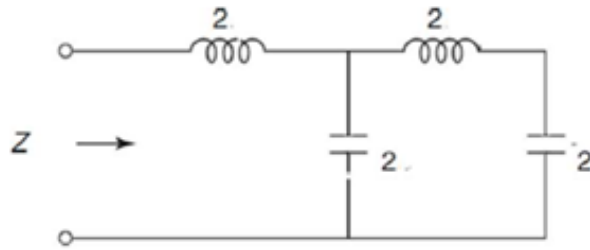


5. State the initial value theorem and find the initial value of the function,  $f(t)$  which have Laplace transform,

$$F(s) = \frac{s^2 + 1}{s(2s + 3)(s + 5)}.$$

6. Find the expression for the current through an RC circuit due to impulse as input.
7. State the properties of a network transfer function.

8. Find the driving point impedance function of the following network.



9. Derive the conditions of reciprocity in a two-port network in terms of its transmission parameters.
10. Consider a two-port network with the open circuit impedance parameter matrix

$$\begin{bmatrix} 2 & 1 \\ 3 & 2 \end{bmatrix}$$

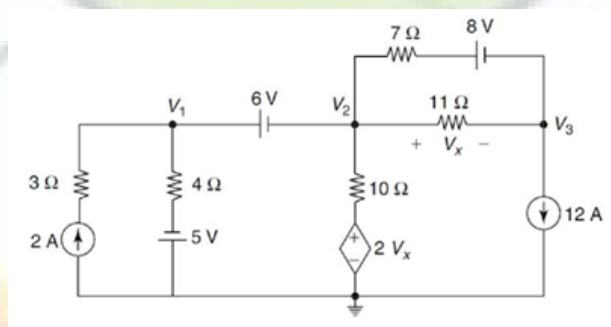
Check whether the network is symmetric and reciprocal.

### PART B

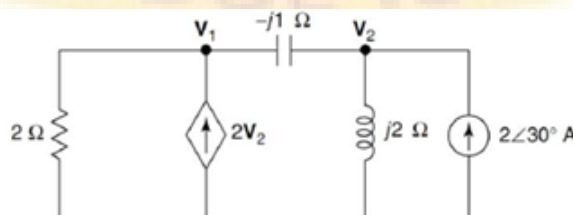
Answer any one question from each module. Each question carries 14 marks

#### Module I

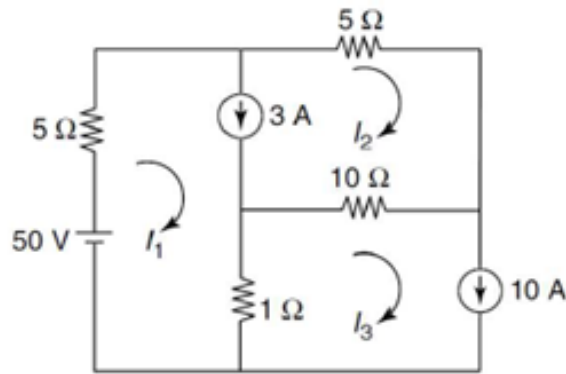
11. a) Using node analysis determine the voltage  $V_x$ . (7)



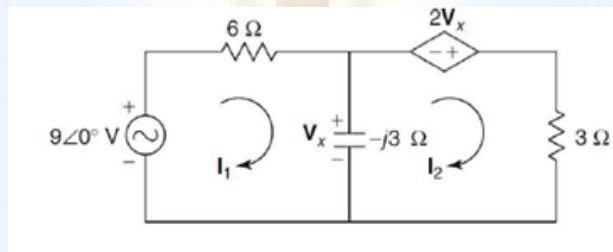
- b) Find the node voltages of the following circuit. (7)



12. a. Find the current through  $10\ \Omega$  resistor using mesh analysis. (7)

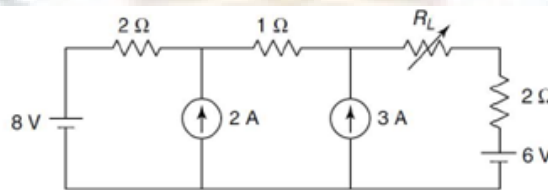


- b. Find the loop current  $I_1$  and  $I_2$  in the given network. (7)

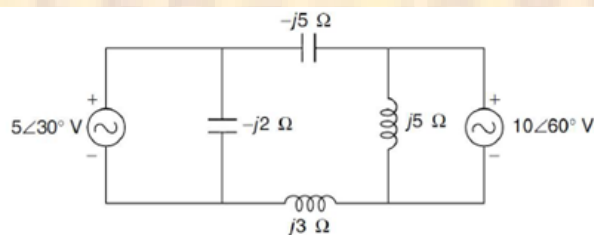


### Module II

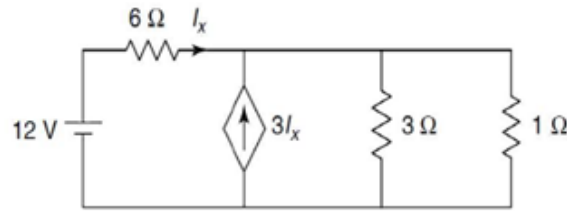
13. a) Find the value of  $R_L$  such that maximum power is transferred to it. Also find the maximum power transferred to  $R_L$ . (8)



- b) Find the current through  $j3\ \Omega$  using superposition theorem. (6)

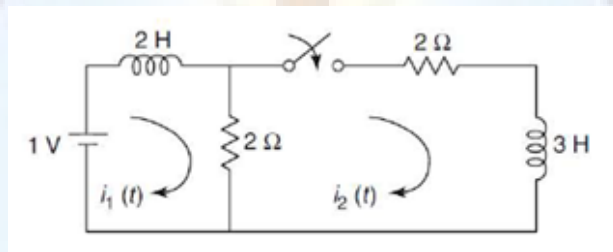


14. Determine the Thevenin and Norton equivalent circuit across the terminals  $1\ \Omega$ . (14)

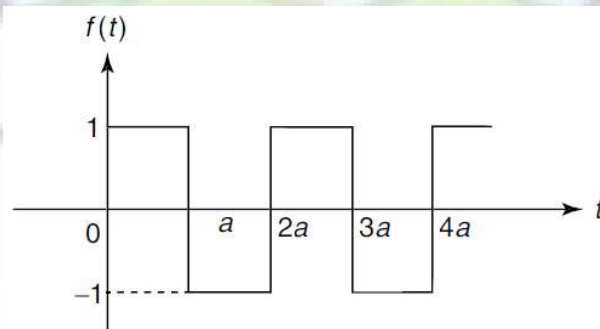


**Module III**

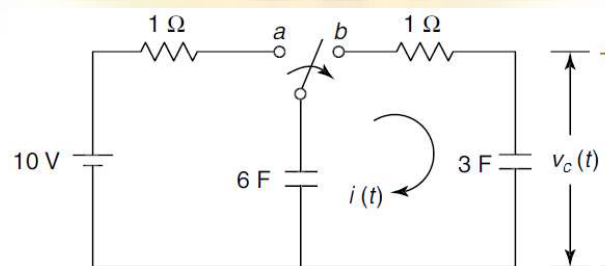
15. a) Find the Laplace transform of the following signals (i)  $f(t) = \int_0^t e^{-4t} \sin 2t dt$  (ii)  $f(t) = \frac{1-e^{-t}}{t}$  (6)
- b) In the circuit, the switch is closed at  $t = 0$ . Determine current through the inductor with inductance  $3H$  for  $t > 0$ . Assume the steady state being reached before  $t = 0$ . (8)



16. a) Find the Laplace transform of the waveform  $f(t)$ .

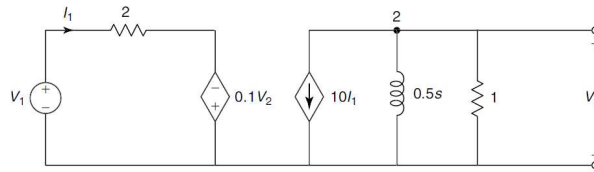


- b) In the given network, the switch is moved from position a to b at  $t = 0$ . Determine the voltage,  $V_c(t)$ . (7)



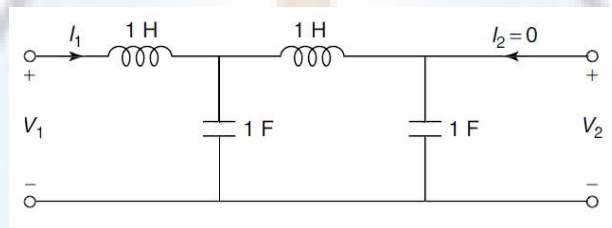
**Module IV**

17. a) Find the driving point admittance function,  $Y_{11} = \frac{I_1}{V_1}$  of the following network. (8)



- b) The voltage of a network is given as  $V(s) = \frac{(s+2)(s+6)}{(s+1)(s+5)}$  Plot the pole-zero diagram and hence obtain  $V(t)$ . (6)

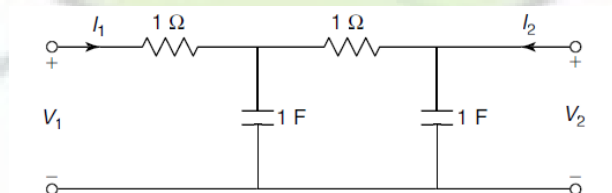
18. Find the network functions  $\frac{V_1}{I_1}$ ,  $\frac{V_2}{V_1}$  and  $\frac{V_2}{I_1}$  of the following network. (14)



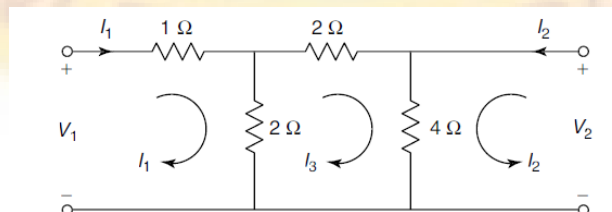
**Module V**

19.

- a) Obtain the admittance parameters for the network. (7)



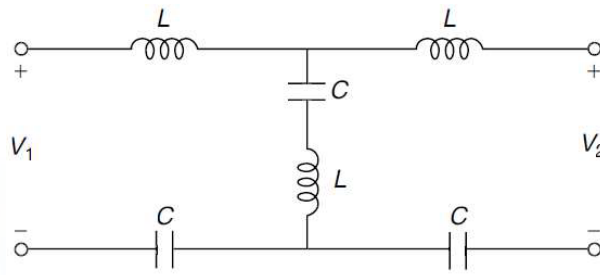
- b) Determine h parameters for the network. Determine whether the network is reciprocal. (7)



20.

- a) Show that when 2 two-port networks are connected in series, the resultant Z-matrix is the sum of Z-matrices of each individual network. (6)

- b) Find the open circuit impedance parameters of the following circuit using the concept of series interconnection of two-port networks.. (8)





| <b>B24HU2T01</b> | <b>BUSINESS<br/>ECONOMICS<br/>AND FINANCIAL<br/>MANAGEMENT</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF<br/>INTRODUCTION</b> |
|------------------|----------------------------------------------------------------|----------|----------|----------|----------|---------------|---------------------------------|
|                  |                                                                | 3        | 0        | 0        | 4        |               |                                 |

**Preamble**

This course will aid and equip the students to comprehend the various concepts in Business Economics and Finance. They will gain an understanding of price, demand, production, costs and revenue. They will also learn about the functioning of various markets and fathom the problems affecting the world of business. They will be introduced to national income accounting and to the financial tools used in personal finance. The students will also gain an insight into business financing and the functioning of the stock market.

**Prerequisites**

Nil

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                                                                                                                                            |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the fundamental concepts and theories of demand, supply and production in relation to various economic issues pertaining to the engineering industry. (Cognitive Knowledge Level: Understand)                                                                                   |
| <b>CO 2</b> | Apply the concepts relating to costs and revenue in the functioning of engineering firms in different market situations and solve industry level business problems using tools like break even analysis. (Cognitive Knowledge Level: Apply)                                                |
| <b>CO 3</b> | Apply the fundamental macroeconomic principles to emerging economic concepts influencing the growth and performance of the economy as a whole like national income accounting, monetary and fiscal policy, balance of payments and international trade. (Cognitive Knowledge Level: Apply) |
| <b>CO 4</b> | Apply the fundamental concepts of financial management to acquire knowledge in the functioning of the Indian financial system and evaluate decisions regarding personal finance. (Cognitive Knowledge Level: Apply)                                                                        |
| <b>CO 5</b> | Demonstrate decision making capability by acquiring knowledge in industrial financing, international financing, stock markets and mutual funds. (Cognitive Knowledge Level: Apply)                                                                                                         |

### Mapping of Course Outcomes with Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 1    | 1    | 0    | 1    | 0    | 0    | 0    | 0    | 1    | 1     | 1     |
| CO 2 | 1    | 1    | 1    | 1    | 1    | 1    | 0    | 0    | 1    | 1     | 1     |
| CO 3 | 1    | 1    | 0    | 1    | 1    | 0    | 0    | 0    | 1    | 1     | 1     |
| CO 4 | 1    | 0    | 1    | 1    | 0    | 1    | 1    | 1    | 1    | 2     | 1     |
| CO 5 | 1    | 1    | 1    | 0    | 0    | 1    | 1    | 1    | 1    | 1     | 1     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                     | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|---------------------|---------------------------------------|
|                  | Test 1<br>(% Marks)   | Test 2<br>(% Marks) |                                       |
| Remember         | 50                    | 30                  | 30                                    |
| Understand       | 50                    | 40                  | 40                                    |
| Apply            |                       | 30                  | 30                                    |
| Analyse          |                       |                     |                                       |
| Evaluate         |                       |                     |                                       |
| Create           |                       |                     |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Quiz/Course project         | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contains 10 questions carrying 3 marks

each. Part B contains 2 questions from each module, out of which one is to be answered. Each question carries 14 marks and can have maximum of two subdivisions.

## **SYLLABUS**

### **MODULE 1 (8 hours)**

#### **Fundamentals of Business Economics**

Introduction - Demand and its determinants - Law of demand - Elasticity of demand: Price, Income and Cross - Measurement of elasticity and its applications (Numerical problems)  
- Supply and its determinants - Determination of Equilibrium Price - Changes in demand and supply and its effects Utility - Law of diminishing marginal utility - Consumer surplus  
- Producer surplus.

Production concepts: Production function - Cobb-Douglas function (Numerical problems)  
- Average product - Marginal product - Law of variable proportions - Law of Returns to Scale.

### **MODULE 2 (7 hours)**

#### **Cost, Revenue and Markets**

Concepts of cost: Opportunity cost - Explicit and implicit cost - Private and social cost- Short run cost curves - Fixed, variable, total, average, and marginal cost curves - Long run cost curves.

Concepts of revenue: Average and marginal revenue - Shutdown point - Break Even analysis (Numerical problems).

Markets: Perfect Competition, Monopoly, Monopolistic Competition, Oligopoly - Cartel and Collusion (Features and equilibrium of a firm) - Product pricing: Cost plus pricing - Target return pricing - Penetration pricing - Predatory pricing - Going rate pricing - Price skimming - Administered pricing.

### **MODULE 3 (7 hours)**

#### **National Income, Inflation and International Trade**

Circular flow of income - Multi-sector model - National income concepts: GNP, GDP, NNP, NI, PI, DPI, PCI - Methods of measuring national income - Difficulties (Numerical problems).

Inflation - Types - Causes and effects - Measures to control inflation - Monetary and fiscal policies - Deflation.

International Trade - Balance of payments - Components - Deficit - Devaluation - Tariff and non-tariff barriers.

## MODULE 4 (7 hours)

### Fundamentals of Financial Management

Introduction - Reserve Bank of India - Functions - Credit control techniques: Quantitative and qualitative techniques - Working capital management - Factors affecting working capital - Management of cash and marketable securities - Receivables management - Balance Sheet - Profit and Loss Account.

Personal Finance: Personal budget - Tracking income and expenses - 50-30-20 budgeting rule - Emergency fund - Debit vs Credit instruments - Diversification of Investments - Shares vs Bonds - Power of Compounding - Financial independence - Types of Insurance - Digital technology in Finance.

## MODULE 5 (7 hours)

### Business Financing

Introduction: The Stock Market: Functions, Problems faced by the stock market in India - Demat account and trading account - Market indices: Sensex and Nifty - Derivatives: Forwards, Futures, Options, Swaps - Mutual Funds - Types.

Sources of business financing: Equity capital - Preference capital - Debenture capital - Term loans - Retained earnings - Money market - Instruments - International Financing - FDI, FII.

### Text Books

1. Dominic Salvatore, *Principles of Microeconomics*, Oxford University Press, 2009.
2. Gregory N. Mankiw, *Principles of Macro Economics*, Cengage Learning India, 2022.
3. Prasanna Chandra, *Financial Management*, McGraw Hill, 2020.

### Reference Books

1. Paul A. Samuelson, *Economics*, McGraw Hill, 2019.
2. A. Koutsoyiannis, *Modern microeconomics*, Palgrave McMillan, 1979.
3. Geetika Piyali Ghosh and Chodhury, *Managerial Economics*, McGraw-Hill, 2017.
4. M. Y. Khan & P. K. Jain, *Financial Management*, McGraw Hill, 2018.
5. Ruddar Datt, *Indian Economy*, S. Chand and Company Ltd., 2018.
6. Dwivedi D. N., *Macro Economics*, McGraw Hill, 2018.
7. Gregory N. Mankiw, *Principles of Micro Economics*, Cengage Learning India, 2020.
8. James C. Van Horne, *Financial Management and Policy*, Pearson Education, 2020.

## COURSE CONTENTS AND LECTURE SCHEDULE

| No. | Topic                                                                                                                                                                                                                                                             | No of Lecture/Tutorial Hours |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | Total Hours                                                                                                                                                                                                                                                       | 36 Hours                     |
|     | <b>Module 1: Fundamentals of Business Economics</b>                                                                                                                                                                                                               | <b>8</b>                     |
| 1.1 | Introduction - Demand and its determinants - Law of demand - Elasticity of demand - Measurement of elasticity and its applications (Numerical problems)                                                                                                           | 2                            |
| 1.2 | Supply and its determinants - Determination of equilibrium price - Changes in demand and supply and its effects                                                                                                                                                   | 2                            |
| 1.3 | Law of diminishing marginal utility - Consumer surplus - producer surplus                                                                                                                                                                                         | 2                            |
| 1.4 | Production concepts: Production function - Cobb-Douglas function (Numerical problems) - Average product - Marginal product - Law of variable proportions - Law of Returns to Scale                                                                                | 2                            |
|     | *Activity 1: OPEC decides to reduce its output of oil. Using demand and supply curves bring out the effect of this on the price of oil in the world market.<br>Activity 2: Derive the determination of the equilibrium price of a super luxury and an economy car |                              |
|     | <b>Module 2: Cost, Revenue and Markets</b>                                                                                                                                                                                                                        | <b>7</b>                     |
| 2.1 | Concepts of cost - Opportunity cost - Explicit and implicit cost - Private and social cost- Short run cost curves - Fixed, variable, total, average and marginal cost curves - Long run cost curves                                                               | 2                            |
| 2.2 | Concepts of revenue - Average and marginal revenue - Shut-down point - Break Even analysis (Numerical problems)                                                                                                                                                   | 2                            |
| 2.3 | Markets: Perfect Competition, Monopoly, Monopolistic Competition, Oligopoly - Cartel and Collusion (Features and equilibrium of a firm)                                                                                                                           | 2                            |
| 2.4 | Product pricing: Cost plus pricing - Target return pricing - Penetration pricing - Predatory pricing - Going rate pricing - Price skimming - Administered pricing                                                                                                 | 1                            |
|     | Activity 1: Determination of equilibrium price and output in oligopoly companies in India<br>Activity 2: Pricing strategy followed by Apple in regard to their mobiles                                                                                            |                              |
|     | <b>Module 3: National Income, Inflation and International Trade</b>                                                                                                                                                                                               | <b>7</b>                     |
| 3.1 | Circular flow of income - Multi-sector model - National income concepts - GNP, GDP, NNP, NI, PI, DPI, PCI - Methods of measuring national income - Difficulties (Numerical problems)                                                                              | 2                            |



|     |                                                                                                                                                                                                                                                                                                |          |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 3.2 | Inflation - Types - Causes and effects - Measures to control inflation - Monetary and fiscal policies - Deflation                                                                                                                                                                              | 2        |
| 3.3 | International Trade - Balance of payments - Components - Deficit                                                                                                                                                                                                                               | 2        |
| 3.4 | Devaluation - Tariff and non-tariff barriers                                                                                                                                                                                                                                                   | 1        |
|     | Activity 1: Compare the present BoP position of India and China<br>Activity 2: Impact of tariff wars in today's global scenario                                                                                                                                                                |          |
|     | <b>Module 4: Financial Management</b>                                                                                                                                                                                                                                                          | <b>7</b> |
| 4.1 | Introduction - Reserve Bank of India - Functions - Credit control techniques: Quantitative and qualitative techniques                                                                                                                                                                          | 2        |
| 4.2 | Working capital management - Factors affecting working capital                                                                                                                                                                                                                                 | 1        |
| 4.3 | Management of cash and marketable securities - Receivables management. Balance Sheet - Profit and Loss Account                                                                                                                                                                                 | 2        |
| 4.4 | Personal Finance: Budget - Tracking income and expenses - 50-30-20 budgeting rule - Emergency fund - Debit vs Credit Cards - Diversification of Investments - Shares vs Bonds - Power of Compounding - Financial independence - Insurance - Types of Insurance - Digital technology in Finance | 2        |
|     | Activity 1: Investigate the historical returns offered by different asset classes.<br>Activity 2: Steps needed to circumnavigate financial challenges like student loans, buying a car, purchasing a home vs renting etc.                                                                      |          |
|     | <b>Module 5: Business Financing</b>                                                                                                                                                                                                                                                            | <b>7</b> |
| 5.1 | Introduction - The Stock Market - Functions, Problems faced by the stock market in India - Demat account and trading account - Market indices: Sensex and Nifty                                                                                                                                | 3        |
| 5.2 | Derivatives: Forwards, Futures, Options, Swaps - Mutual Funds - Types                                                                                                                                                                                                                          | 1        |
| 5.3 | Sources of business financing: Equity capital - Preference capital - Debenture capital - Term loans - Retained earnings                                                                                                                                                                        | 2        |
| 5.4 | International Financing - FDI, FII                                                                                                                                                                                                                                                             | 1        |
|     | Activity 1: Research and present the stock performance of a company.<br>Activity 2: Investigate the impact of foreign direct investment into India taking the examples of multinational companies                                                                                              |          |



## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1)**

1. State the Law of demand.
2. With the help of a figure, elucidate the concept of consumer surplus.
3. Define utility. State the Law of diminishing marginal utility.

### **Course Outcome 2 (CO 2)**

1. Distinguish between explicit and implicit cost.
2. Bring out the relationship between average and marginal revenue.
3. How does a firm under monopoly attain equilibrium?

### **Course Outcome 3 (CO 3)**

1. With the help of a figure, examine the circular flow of income in a multi sector economy.
2. State the government measures to control inflation.
3. What are non-tariff barriers? Give two examples.

### **Course Outcome 4 (CO 4)**

1. Mention any four functions of the RBI.
2. Elucidate the concept of working capital management. State the main factors influencing it.
3. Clarify the significance of an emergency fund? Mention its advantages.

### **Course Outcome 5 (CO 5)**

1. Elucidate the main problems faced by the stock market in India.
2. Clarify the significance of mutual funds? Mention the main types of mutual funds.
3. Distinguish between FDI and FII.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 3**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2026**

**Course Code: : B24HU2T01**

**Course Name: : BUSINESS ECONOMICS AND FINANCIAL MANAGEMENT**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks.**

1. With the help of a figure, elucidate the concept of consumer surplus.
2. A tea company sold 40000 kg of tea when the price of coffee was Rs.50 per kg. Later they were able to sell 45000 kg when the price of coffee increased to Rs.70 per kg. Calculate the cross elasticity of demand for tea.
3. Distinguish between explicit and implicit cost.
4. List the features of a firm under perfect competition.
5. Define cost plus pricing. Mention its advantage.
6. Write a note on non-tariff barriers. Give two examples.
7. Define Cash Reserve Ratio.
8. Write a note on the significance of receivables management.
9. Distinguish between demat account and trading account.
10. What is FDI? Mention two of its merits.

**PART B**

**Answer any one question from each module. Each question carries 14 marks.**

11. (a) State the Law of Demand. Also mention the assumptions and exceptions of the law. (7 marks)
- (b) What is the Cobb- Douglas production function? Mention its feature. If the production function of a firm is  $Q = 30 L^{1/2} K^{1/2}$ , find out the average and marginal product of labour from the function, if 225 units of labour is combined with 196 units of capital. (7 marks)

**OR**

12. (a) State the Law of diminishing marginal utility. Also mention the assumptions and importance of the law (7 marks)
- (b) Define Income elasticity. When the income of a consumer was Rs. 50000 per month, the quantity demanded of a good was 100 units. When his income increased to Rs.80000, his demand increased to 110 units. Is the good a normal or an inferior one? Give reason. (7 marks)
13. (a) State the features of a firm under perfect competition. With the help of a figure, explain the determination of equilibrium price and output under perfect competition. (7 marks)
- (b) A firm sells its product at Rs.400 per unit. To produce a unit, it needs raw materials for Rs. 150, labour for Rs.70 and incurs other variable expenses for Rs. 40. The firm's fixed expenses are Rs.15,00,000. Find the breakeven quantity of the firm. (7 marks)

**OR**

14. (a) State the features of a firm under monopolistic competition. With the help of a figure, explain the determination of equilibrium price and output under monopolistic competition (7 marks)
- (b) The value of the total sales of a company is Rs. 100000. Its fixed cost is Rs. 20000, while its variable cost is Rs.50000. Calculate
- (a) the P/V ratio
  - (b) breakeven point
  - (c) Margin of safety at this level of sales
  - (d) If it sells each unit for Rs.20, how many units should the company sell to break even?
  - (e) Find the sales required to earn a profit of Rs.20000. (7 marks)
15. (a) With the help of a figure, examine the circular flow of income in a multi sector economy. (7 marks)

- (b) From the following data,
- (a) Gross National Product = Rs 14700 crores
  - (b) GST = Rs 1100 crores
  - (c) Undisbursed Profit = Rs 2000 crores
  - (d) Corporate Income Tax = Rs 1000 crores
  - (e) Depreciation = Rs 1500 crores
  - (f) Net Factor Income from abroad = Rs 5200 crores
  - (g) Income Tax = Rs 500 crores
  - (h) Subsidies = Rs 400 crores
  - (i) Social Security Contribution = Rs 300 crores

Calculate

- (i) GDP
- (ii) NI
- (iii) PI

(7 marks)

**OR**

16. (a) Elucidate the economic problem of inflation. What are its main types? State the government measures to control inflation. (7 marks)
- (b) In an economy, the total expenditure of the people on various goods and services is Rs 2000 crores. The government spending is Rs 500 crores while the total investment is Rs 300 crores. Exports are Rs 200 crores and imports are Rs. 100 crores. The depreciation is Rs 80 crores. Find the value of GNP. (7 marks)
17. (a) Discuss the functions of the RBI. What are the main quantitative techniques used by the RBI? (7 marks)
- (b) State the meaning of balance sheet in accounting. Draw a format of the balance sheet showing the different entries. (7 marks)

**OR**

18. (a) Write a note on the management of cash and marketable securities. (7 marks)
- (b) State the significance of profit and loss account. Illustrate a format of the profit and loss account. (7 marks)
19. (a) Elaborate the main functions performed by the stock market in an economy. (7 marks)
- (b) Elucidate the various sources of business financing available to companies. (7 marks)

**OR**

20. (a) Elaborate the meaning of mutual funds. Discuss the different types of mutual funds. (7 marks)
- (b) Distinguish between FDI and FII. (7 marks)

| B24EC2L03 | LOGIC CIRCUIT<br>DESIGN LAB | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|-----------------------------|---|---|---|---|--------|-------------------------|
|           |                             | 0 | 0 | 3 | 2 | 2      | 2024                    |

### Preamble

This course aims to expose students to digital logic design by having them model digital circuits using LTSpice and construct logic circuits using fundamental logic gates and ICs.

### Prerequisite

B24EC1T03 : LOGIC CIRCUIT DESIGN

### Course Outcomes

After the completion of the course the student will be able to

|      |                                                                                                                                                                                                   |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Implement basic combinational logic circuits, arithmetic circuits, and Boolean functions using logic gates, universal gates, and standard ICs. [Apply]                                            |
| CO 2 | Design and verify combinational logic circuits using multiplexers, demultiplexers, and decoder circuits for realizing digital functions. [Apply]                                                  |
| CO 3 | Construct and analyze sequential logic circuits including flip-flops, counters, shift registers, and random sequence generators using digital ICs. [Analyze]                                      |
| CO 4 | Analyze the functionality and performance of digital logic circuits by interpreting experimental and simulation results, and verify their correctness against theoretical expectations. [Analyze] |
| CO 5 | Simulate random processes and understand their statistics. [Apply]                                                                                                                                |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    | 2    | 1    | 2    |      |      |      |      |       | 1     |
| CO 2 | 3    | 2    | 3    | 1    | 2    |      |      |      |      |       | 1     |
| CO 3 | 3    | 2    | 3    | 2    | 2    |      |      |      |      |       | 1     |
| CO 4 | 2    | 2    | 2    | 2    | 3    |      |      |      |      |       | 1     |
| CO 5 | 2    | 3    | 2    | 3    | 2    |      |      |      | 1    |       | 1     |

## Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hour       |

## Continuous Internal Evaluation Pattern

|                       |          |
|-----------------------|----------|
| Attendance            | 10 marks |
| Continuous Assessment | 20 marks |
| Internal Test         | 15 marks |
| Lab Record            | 5 marks  |

## End semester Examination pattern

|                                |          |
|--------------------------------|----------|
| Preliminary Work               | 30 marks |
| Performance and Implementation | 20 marks |
| Result and Inference           | 30 marks |
| Viva                           | 20 marks |

## SYLLABUS

### LIST OF EXPERIMENTS

It is compulsory to conduct a minimum of 6 experiments from Part A and a minimum of 4 experiments from Part B.

#### PART A(Any 6)

|    |                                                                                                 |
|----|-------------------------------------------------------------------------------------------------|
| 1  | Realization of functions using basic and universal gates (SOP and POS forms).                   |
| 2  | Design and Realization of half/full adder and subtractor using basic gates and universal gates. |
| 3  | 4 bit adder/subtractor and BCD adder using 74283(4-bit Full Adder IC).                          |
| 4  | Realization of combinational circuits using MUX DEMUX ICs.                                      |
| 5  | Study of Flip Flops: S-R, D, T, JK and Master Slave JK FF using NAND gates.                     |
| 6  | Asynchronous Counter:3 bit up/down counter ,Realization of Mod N counter.                       |
| 7  | Synchronous Counter: Realization of 3-bit up/down counter,Realization of Mod-N counters.        |
| 8  | Ring counter and Johnson Counter. (using FF or 74194 ic(4 bit parallel access shift register).  |
| 9  | Realization of counters using counter IC's and show the output using 7-segment display          |
| 10 | Random Sequence generator using LFSR(linear-feedback shift register).                           |

#### PART B(Any 4)



|   |                                                                                                                                                                                                                                                                  |
|---|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Adders in LTSpice (a) Development of half adder, full adder, half subtractor and full subtractor using LTSpice.                                                                                                                                                  |
| 2 | MUX and DEMUX in LTSpice (a) Development of a 8x1 MUX and 1x8 DEMUX using LTSpice. (b) Realize the logic function $f(A, B, C) = \sum m(0, 1, 3, 7)$ , $f(A, B, C, D) = \sum m(0, 1, 3, 7, 10, 12)$ by partitioning the truth table and full adder using 8:1 MUX. |
| 3 | Flip-Flop Conversion using LTSpice. (a) Implement and test the conversions such as T to D, D to T, J-K to T and J-K to D.                                                                                                                                        |
| 4 | Counters and Random Sequence Generator (a) Development of binary decade counter using LTSpice. (b) Development of Random Sequence Generator using LTSpice.                                                                                                       |
| 5 | Universal Shift Register using LTSpice (a) Development of a 4-bit universal shift register using D-flip-flops. (b) Development of 4-bit Ring and Johnson counters using JK-flip-flops.                                                                           |
| 6 | BCD to Seven Segment Decoder using LTSpice. (a) Make a gate level design of a seven segment decoder and test it with seven segment display using LTSpice.                                                                                                        |

### Reference Books

1. Digital design. Mano M. Morris, India: Prentice Hall.
2. Digital Electronics, G. K. Kharate, OUP India.
3. Digital Fundamentals, Thomas L Floyd, Pearson India.

| B24EC2L04 | ELECTRONIC<br>CIRCUITS LAB | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|----------------------------|---|---|---|---|--------|-------------------------|
|           |                            | 0 | 0 | 3 | 2 | 2      | 2024                    |

**Preamble**

The Electronic Circuits Lab is designed to provide hands-on experience with the analysis, design, and implementation of MOSFET-based circuits and power amplifiers. By the end of the lab sessions, students will develop practical skills in circuit design, testing, and simulation, reinforcing theoretical knowledge essential for careers in analog electronics, VLSI design, and related fields.

**Prerequisite**

B24EC1T04 : Analog Circuit I

**Course Outcomes**

After the completion of the course the student will be able to

|             |                                                                                                                      |
|-------------|----------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand and analyze the operation of MOSFETs. [Understand, Analyze]                                               |
| <b>CO 2</b> | Utilize MOSFETs in switching and resistive applications. [Apply]                                                     |
| <b>CO 3</b> | Design and analyze MOSFET biasing and amplifier circuits [Apply]                                                     |
| <b>CO 4</b> | Analyze and simulate MOSFET-based differential amplifiers, cascode amplifiers, and current mirrors. [Apply, Analyze] |
| <b>CO 5</b> | Simulate and analyze the efficiency of a Class AB amplifier using BJTs                                               |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| <b>CO 1</b> | 3   | 3   | 3   |     |     |     |     |     |     |      | 1    |
| <b>CO 2</b> | 3   | 3   | 1   |     |     |     |     |     |     |      | 1    |
| <b>CO 3</b> | 3   | 3   | 3   | 1   | 2   |     |     |     |     |      | 1    |
| <b>CO 4</b> | 3   | 3   | 1   | 1   | 2   |     |     |     |     |      | 1    |
| <b>CO 5</b> | 3   | 3   | 3   | 1   | 2   |     |     |     |     |      | 1    |

**Mark Distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hour       |

### Continuous Internal Evaluation Pattern

|                       |          |
|-----------------------|----------|
| Attendance            | 10 marks |
| Continuous Assessment | 20 marks |
| Internal Test         | 15 marks |
| Lab Record            | 5 marks  |

### End semester Examination pattern

|                                |          |
|--------------------------------|----------|
| Preliminary Work               | 30 marks |
| Performance and Implementation | 20 marks |
| Result and Inference           | 30 marks |
| Viva                           | 20 marks |

## SYLLABUS

### LIST OF EXPERIMENTS

Any three experiments among this must be done in hardware.

|    |                                                                                                                                                                                   |
|----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | Study the I-V characteristics of an N-channel MOSFET and plot the drain current ( $I_D$ ) vs. drain-source voltage ( $V_{DS}$ ) for different gate-source voltages ( $V_{GS}$ ).  |
| 2  | Design and analyze the Q-point of a MOSFET with fixed biasing.                                                                                                                    |
| 3  | Design and analyze a MOSFET as a switch.                                                                                                                                          |
| 4  | Analyze a MOSFET operating as an active resistor.                                                                                                                                 |
| 5  | Study the operation of a simple MOSFET current mirror.                                                                                                                            |
| 6  | Design and analyze a common-source amplifier and plot the Frequency Response.                                                                                                     |
| 7  | Design and set up a source follower(Common Drain) circuit for voltage buffering and signal amplification.                                                                         |
| 8  | Implement and evaluate a MOS differential amplifier, study its transfer characteristics, and measure differential gain, common-mode gain, and common-mode rejection ratio (CMRR). |
| 9  | Design and Simulate Cascode Amplifier (MOS CS-CG Configuration) .                                                                                                                 |
| 10 | Simulate a Class AB amplifier using BJT and analyze its efficiency                                                                                                                |

### Reference Books

1. Adel S. Sedra and Kenneth C. Smith "Microelectronic Circuits"
2. Behzad Razavi, Design of Analog CMOS Integrated Circuits
3. Phillip E. Allen and Douglas R. Holberg, CMOS Analog Circuit Design.
4. Robert L. Boylestad and Louis Nashelsky, Electronic Devices and Circuit Theory

| B24MC2T04 | UNIVERSAL HUMAN<br>VALUES AND<br>CONSTITUTIONAL<br>RIGHTS | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|-----------------------------------------------------------|---|---|---|---|--------|-------------------------|
|           |                                                           | 2 | 0 | 0 | 2 | P/F    | 2024                    |

**Preamble**

This course explores various dimensions of human existence, beginning with self-awareness and an understanding of essential needs such as prosperity, happiness, inner peace, and harmonious relationships. It also introduces the preamble and key features of the Indian Constitution, along with the Directive Principles of State Policy, highlighting their importance in shaping governance and promoting social welfare. By the end of the course, students will be better equipped to act responsibly, address challenges with sustainable solutions, and foster positive human relationships grounded in an understanding of human nature.

**Prerequisites**

Nil

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                                                                                  |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the importance of value education for holistic development and to fulfill human aspirations. (Cognitive Knowledge Level : Understand)                                                                                 |
| <b>CO 2</b> | Develop more awareness of themselves, and their surroundings (family, society, nature) to build harmonious and respectful relationships. (Cognitive Knowledge Level : Apply)                                                     |
| <b>CO 3</b> | Understand and appreciate the preamble and other features in the Indian Constitution to promote responsible citizenship. (Cognitive Knowledge Level : Understand)                                                                |
| <b>CO 4</b> | Understand the fundamental rights and duties enshrined in the Indian Constitution and the Directive Principles of State Policy and their role in shaping governance and social welfare. (Cognitive Knowledge Level : Understand) |

### Mapping of Course Outcomes with Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 |      |      |      |      |      | 2    | 2    | 1    | 1    | 1     | 2     |
| CO 2 |      |      |      |      |      | 2    | 2    | 2    | 1    | 1     | 2     |
| CO 3 |      |      |      |      |      | 2    | 2    |      | 2    |       | 2     |
| CO 4 |      |      |      |      |      | 2    | 2    |      | 2    |       | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|---------------------------------------|
|                  | Test 1 (% Marks)      |                                       |
| Remember         | 30                    | 30                                    |
| Understand       | 60                    | 60                                    |
| Apply            | 10                    | 10                                    |
| Analyse          |                       |                                       |
| Evaluate         |                       |                                       |
| Create           |                       |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 50        | 50        | 2 hours      |

### Continuous Internal Evaluation Pattern

|                                                                                     |          |
|-------------------------------------------------------------------------------------|----------|
| Attendance                                                                          | 10 marks |
| Continuous Assessment Test (1 number)<br>(Conducted for 50 marks and reduced to 25) | 25 marks |
| Assignments/Quiz/Course Project/Seminar                                             | 10 marks |
| Self Study                                                                          | 5 marks  |

### End Semester Examination Pattern

There will be two parts, Part A and Part B. Part A contains 4 questions carrying 3 marks from each module. Part B contains 2 questions from each module out of which one is to be answered. In Part B, each question of first two modules carries 9 marks and each question of last two modules carries 10 marks.

## SYLLABUS

### MODULE 1 (6 hours)

#### Introduction to Values

The need of Value Education-Guidelines for Value Education, Self-exploration as the Process for Value Education - Two parts, Important implications of Self Exploration, Continuous Happiness and Prosperity - A Look at Basic Human Aspirations - Right Understanding, Relationship and Physical Facility (Holistic Development and the Role of Education) - Method to fulfill the Basic Human Aspirations.

### MODULE 2 (5 hours)

#### Harmony in the Human Being, Family and Society

Understanding Human being as the Co-existence of the Self and the Body - Distinguishing between the Needs of the Self and the Body - Harmony of the Self with the Body - Harmony in the Family - the Basic Unit of Human Interaction - Understanding Harmony in the Society.

### MODULE 3 (5 hours)

#### Introduction to Constitution of India

Definition and Historical Background of the Constitution - Salient Features of the Constitution - Preamble of the Constitution - Union and Its Territory - Meaning and Types of Citizenship - Termination of Citizenship.

### MODULE 4 (8 hours)

#### State Policies and Fundamental Rights

Definition of the State - Fundamental Rights - General Nature and Classification - Right to Equality and Right to Freedom - Right Against Exploitation - Right to Freedom of Religion - Cultural and Educational Rights - Right to Constitutional Remedies - Protection Against Conviction for Offences - Right to Information (RTI) and Its Applications - Directive Principles of State Policy - Classification of Directives - Fundamental Duties.

#### Text Books

1. R R Gaur, R Asthana, G P Bagaria, *A Foundation Course in Human Values and Professional Ethics*, Excel Books, New Delhi, 3rd ed., 2023.
2. R R Gaur, R Asthana, G P Bagaria, *The Teacher's Manual for a Foundation Course in Human Values and Professional Ethics*, Excel Books, New Delhi, 3rd ed., 2023.



3. D D Basu, *Introduction to the constitution of India*, Lexis Nexis, New Delhi, 26th ed., 2022.
4. P M Bhakshi, *The constitution of India*, Universal Law, 19th ed., 2023.

### Reference Books

1. M Govindarajan, S Natarajan and V S Senthil Kumar, *Engineering Ethics*, PHI Learning Private Ltd, 2012.
2. R S Naagarazan, *A text book on professional ethics and human values*, New age international (P) limited, New Delhi, 2006
3. Ministry of Law and Justice,. Hayt W. H., Kemmerly J. E., and Durbin S. M., *The constitution of India*, Govt of India, New Delhi, 2019.
4. J N Pandey, *The constitutional Law of India*, Central Law Agency, Allahabad, 51th ed., 2019.
5. M V Pylee, *Indias Constitution*, S Chand and Company, New Delhi, 16th ed., 2016.

## COURSE CONTENTS AND LECTURE SCHEDULE

| No. | Topic                                                                                                    | No of Lecture/Tutorial Hours |
|-----|----------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1: Introduction to Values</b>                                                                  | <b>6</b>                     |
| 1.1 | The Need of Value Education - Guidelines for Value Education                                             | 1                            |
| 1.2 | Self-exploration as the Process for Value Education - Two Parts                                          | 1                            |
| 1.3 | Important implications of Self Exploration                                                               | 1                            |
| 1.4 | Continuous Happiness and Prosperity - A Look at Basic Human Aspirations                                  | 1                            |
| 1.5 | Right Understanding, Relationship and Physical Facility (Holistic Development and the Role of Education) | 1                            |
| 1.6 | Method to fulfill the Basic Human Aspirations                                                            | 1                            |
|     | <b>Module 2: Harmony in the Human Being, Family and Society</b>                                          | <b>5</b>                     |
| 2.1 | Understanding Human being as the Co-existence of the Self and the Body                                   | 1                            |
| 2.2 | Distinguishing between the Needs of the Self and the Body                                                | 1                            |
| 2.3 | Harmony of the Self with the Body                                                                        | 1                            |
| 2.4 | Harmony in the Family - the Basic Unit of Human Interaction                                              | 1                            |
| 2.5 | Understanding Harmony in the Society                                                                     | 1                            |
|     | <b>Module 3: Introduction to Constitution of India</b>                                                   | <b>5</b>                     |
| 3.1 | Definition and Historical Background of the Constitution                                                 | 1                            |
| 3.2 | Salient Features of the Constitution                                                                     | 1                            |
| 3.3 | Preamble of the Constitution - Union and Its Territory                                                   | 1                            |
| 3.4 | Meaning and Types of Citizenship                                                                         | 1                            |
| 3.5 | Termination of Citizenship                                                                               | 1                            |
|     | <b>Module 4: State Policies and Fundamental Rights</b>                                                   | <b>8</b>                     |
| 4.1 | Definition of the State - Fundamental Rights - General Nature and Classification                         | 1                            |
| 4.2 | Right to Equality and Right to Freedom - Right Against Exploitation - Right to Freedom of Religion       | 1                            |
| 4.3 | Cultural and Educational Rights - Right to Constitutional Remedies                                       | 1                            |
| 4.4 | Protection Against Conviction for Offences                                                               | 1                            |
| 4.5 | Right to Information (RTI) and Its Applications                                                          | 1                            |
| 4.6 | Directive Principles of State Policy                                                                     | 1                            |
| 4.7 | Classification of Directives                                                                             | 1                            |
| 4.8 | Fundamental Duties                                                                                       | 1                            |
|     | Total Hours                                                                                              | <b>24 Hours</b>              |

## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1)**

1. Explain the basic guidelines for value education. What is the need for these guidelines?
2. Explain the process of self-exploration. What is the expected result of self-exploration?
3. What are the basic human aspirations and what are the requirements to fulfill them? Support your answer with two examples.

### **Course Outcome 2 (CO 2)**

1. Distinguish between 'animal consciousness' and 'human consciousness'.
2. 'Relationship is - between one Self (I1) and another Self (I2)'. Examine this statement.
3. What is the building block for harmony in the society? Explain with examples.

### **Course Outcome 3 (CO 3)**

1. Describe the historical background of the Indian Constitution.
2. Explain the salient features of the Indian Constitution.
3. Summarize the importance of preamble in the implementation of constitution.

### **Course Outcome 4 (CO 4)**

1. What are fundamental rights? Examine each of them.
2. Examine the scope of freedom of speech and expression underlying the constitution.
3. Explain the concept of Union and its territory.
4. What is the fee for seeking information from Central Government Public Authorities?
5. Explain the provision of appeal under the RTI Act.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

THIRD SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2025

**Course Code: : B24MC2T04**

**Course Name: UNIVERSAL HUMAN VALUES AND CONSTITUTIONAL RIGHTS**

Max. Marks: 50

Duration: 2 hours

**PART A**

**Answer all questions. Each question carries 3 marks.**

1. Identify the solution which helps human being to transform from animal Consciousness to human consciousness.
2. What is the building block for harmony in the society?
3. Define and explain the term Constitution.
4. "The freedom of speech and expression is subject to reasonable restrictions". Explain the statement.

**PART B**

**Answer any one question from each module**

5. Explain the basic guidelines for value education. What is the need for these guidelines?  
(9 marks)

**OR**

6. Choose any five things that you consider as human values. Write all the basic guidelines, and check if they satisfy the basic guidelines.  
(9 marks)

7. Distinguish between 'animal consciousness' and 'human consciousness'.

(9 marks)

**OR**

8. 'Relationship is - between one Self (I1) and another Self '. Examine this statement

(9 marks)

9. Summarize the various methods of acquiring Indian citizenship.

(10 marks)

**OR**

10. Examine the salient features of the Indian constitution.

(10 marks)

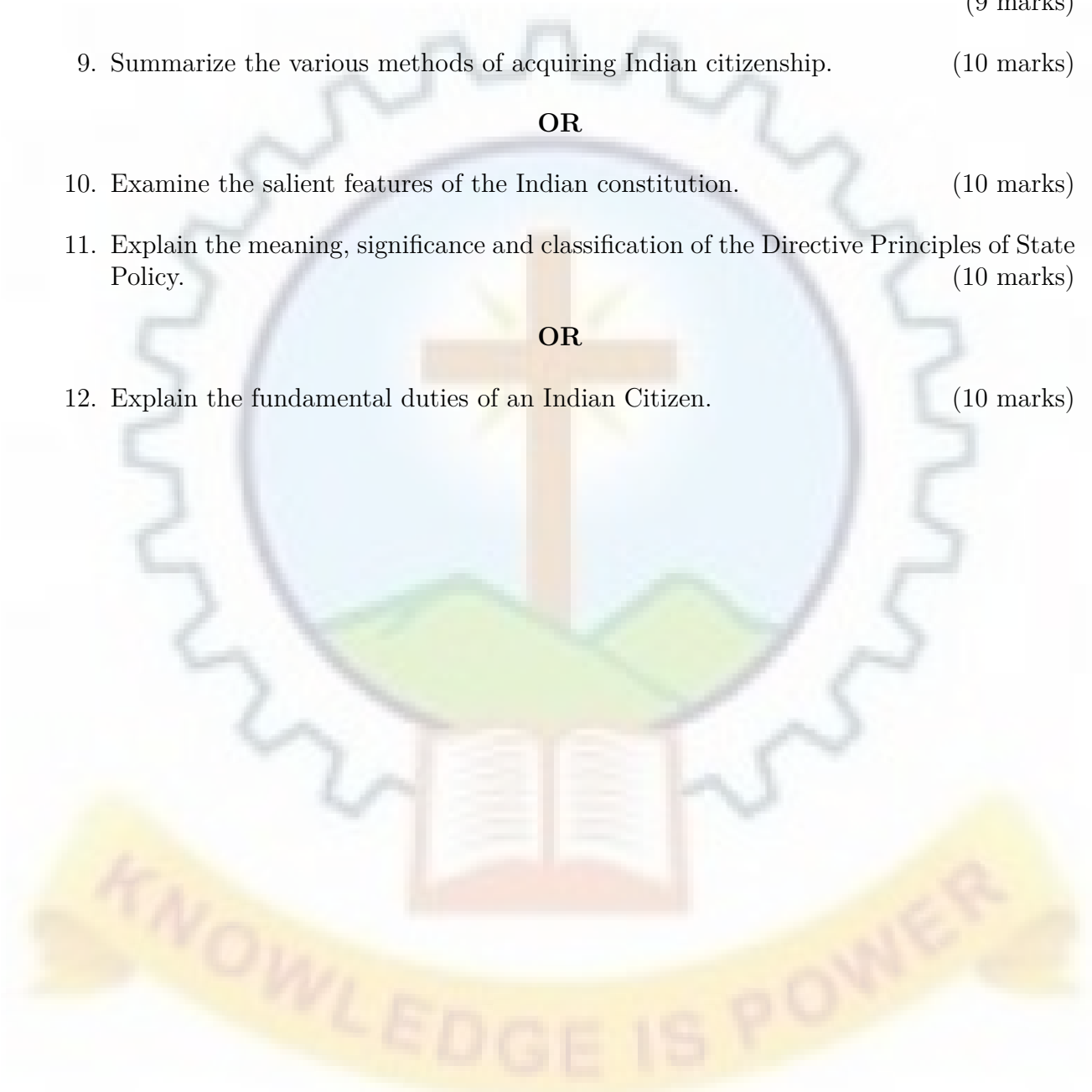
11. Explain the meaning, significance and classification of the Directive Principles of State Policy.

(10 marks)

**OR**

12. Explain the fundamental duties of an Indian Citizen.

(10 marks)



| B24MC2T05 | ENERGY<br>CONSERVATION<br>AND<br>ENVIRONMENTAL<br>SUSTAINABILITY | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|------------------------------------------------------------------|---|---|---|---|--------|-------------------------|
|           |                                                                  | 2 | 0 | 0 | 2 | P/F    | 2024                    |

### Preamble

This course aims to equip students with fundamental knowledge of energy resources, the need for energy conservation, and the importance of environmental sustainability. It emphasizes the role of engineers in adopting renewable energy technologies, reducing environmental impact, and promoting sustainable development for a greener and more resilient future.

### Prerequisites

Nil

### Course Outcomes

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                                  |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Classify various energy resources and describe the importance of energy conservation (Cognitive Knowledge Level: Understand)                                                     |
| <b>CO 2</b> | Explain the principles of renewable energy systems and their applications (Cognitive Knowledge Level: Understand)                                                                |
| <b>CO 3</b> | Recognize major environmental impacts due to energy consumption and explain basic pollution control measures. (Cognitive Knowledge Level: Understand)                            |
| <b>CO 4</b> | Describe sustainability concepts and apply simple strategies for environmental protection and green practices in day-to-day engineering tasks (Cognitive Knowledge Level: Apply) |



### Mapping of Course Outcomes with Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 1    |      |      |      | 2    | 2    |      |      |       |       |
| CO 2 | 3    | 1    | 1    |      |      | 1    | 2    |      |      |       |       |
| CO 3 | 2    | 2    |      |      |      | 2    | 3    | 1    |      |       |       |
| CO 4 | 2    | 1    | 2    |      |      | 2    | 3    | 1    | 1    | 1     |       |

### Assessment Pattern

| Bloom's Category | Continuous Assessment | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|---------------------------------------|
|                  | Test 1 (% Marks)      |                                       |
| Remember         | 30                    | 30                                    |
| Understand       | 50                    | 50                                    |
| Apply            | 20                    | 20                                    |
| Analyse          |                       |                                       |
| Evaluate         |                       |                                       |
| Create           |                       |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 100         | 50        | 50        | 2 hours      |

### Continuous Internal Evaluation Pattern

|                                                                                     |          |
|-------------------------------------------------------------------------------------|----------|
| Attendance                                                                          | 10 marks |
| Continuous Assessment Test (1 number)<br>(Conducted for 50 marks and reduced to 25) | 25 marks |
| Assignment/Quiz/Course Project/Seminar                                              | 10 marks |
| Self Study                                                                          | 5 marks  |

### End Semester Examination Pattern

There will be two parts, Part A and Part B. Part A contains 4 questions carrying 3 marks each. Part B contains 2 questions from each module out of which one has to be answered. In Part B, each question of first two modules carries 9 marks and each question of last two modules carries 10 marks.

## **SYLLABUS**

### **MODULE 1 (6 hours)**

#### **Energy Resources and Conservation**

Types of Energy Resources: Renewable and Non-renewable (with examples), Global and Indian Energy Scenarios, Importance of Energy Conservation, Energy Policy and Planning. Energy Auditing and Efficiency Improvement Techniques - Case studies, Energy-efficient Buildings and Smart Cities.

### **MODULE 2 (6 hours)**

#### **Renewable Energy Technologies**

Solar Energy, Wind Energy, Other Renewable Sources: Biomass and bioenergy systems, small hydropower, ocean thermal, wave, and tidal energy, Geothermal energy.

Energy Storage and Smart Grid Integration: Battery technologies - Role in renewable energy conservation and stability - Decentralized generation and net metering, Advanced and Emerging Technologies: Green hydrogen - Floating solar farms - Offshore wind.

### **MODULE 3 (6 hours)**

#### **Environmental Impact and Pollution Control**

Pollution Types and Sources: Air pollution: industrial emissions, vehicular sources - Water pollution: domestic, industrial, agricultural waste - Soil pollution: hazardous waste, agro-chemicals, Pollution Control Methods: Physical, chemical, biological techniques - Air & water treatment technologies.

Climate Change and Global Warming: Greenhouse gases and carbon footprint - International agreements, Waste Management Strategies - 3Rs (Reduce, Reuse, Recycle) - waste-to-energy, Environmental Regulations in India: Environmental Protection Act, Air & Water Acts - Hazardous Waste Management Rules, Carbon Neutrality and Zero-emission Policies.

### **MODULE 4 (6 hours)**

#### **Sustainability and Green Practices**

Principles of Sustainable Development: Intergenerational equity, resource efficiency - Link with UN Sustainable Development Goals (SDGs), Green Buildings and Infrastructure, Green Certification Systems, Carbon Credits.

Carbon Pricing and Energy Subsidies: Internal carbon pricing by organizations - Government schemes, Life Cycle Assessment (LCA): Phases of LCA: Goal definition, inventory, impact assessment - Smart Sustainable Cities and Resilient Infrastructure: Urban planning for sustainability.

### **Text Books and References**

1. Charles M. Gottschalk, *Industrial Energy Conservation*, John Wiley & Sons, 1996.
2. G. D. Rai, *Non-Conventional Energy Sources*, Khanna Publishers.
3. R. R. Rao, *Environmental Science and Engineering*, PHI.
4. Craig B. Smith, *Energy Management Principles*, Pergamon Press.
5. Paul O'Callaghan, *Energy Management*, McGraw Hill Book Co.
6. Wayne C. Turner, *Energy Management Hand Book*, The Fairmount Press, Inc., 1997.
7. Allen, D. T. and Shonnard, D. R., *Sustainability Engineering: Concepts, Design and Case Studies*, Prentice Hall.
8. Bradley, A. S, Adebayo, A. O., Maria, P., *Engineering applications in sustainable design and development*, Cengage learning.

## COURSE CONTENTS AND LECTURE SCHEDULE

| No. | Topic                                                                                                                                                       | No of Lecture/Tutorial Hours |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1: Energy Resources and Conservation</b>                                                                                                          | <b>6</b>                     |
| 1.1 | Types of Energy Resources (Renewable and Non-renewable), examples. Global and Indian Energy Scenario: Consumption and production trends, sector-wise demand | 1                            |
| 1.2 | Energy Conservation: Residential, Industrial, Transport sectors – behavioural and technological interventions                                               | 1                            |
| 1.3 | Energy Policy and Planning: National Energy Policy, Energy Conservation Act, BEE initiatives                                                                | 1                            |
| 1.4 | Energy Auditing: Preliminary and Detailed audits, Performance Indicators, Case Studies                                                                      | 2                            |
| 1.5 | Energy-efficient Buildings and Smart Cities: Passive design, daylighting, automation                                                                        | 1                            |
|     | <b>Module 2: Renewable Energy Technologies</b>                                                                                                              | <b>6</b>                     |
| 2.1 | Solar Energy: PV systems, solar thermal, rooftop/grid-tied applications                                                                                     | 1                            |
| 2.2 | Wind Energy: Onshore/offshore systems, hybrid solar-wind systems                                                                                            | 1                            |
| 2.3 | Other Renewables: Biomass, small hydro, ocean, tidal, geothermal energy                                                                                     | 1                            |
| 2.4 | Energy Storage: Battery types, conservation role, stability, smart grid integration                                                                         | 1                            |
| 2.5 | Smart Grids and Net Metering: Decentralized generation                                                                                                      | 1                            |
| 2.6 | Advanced Technologies: Green hydrogen, floating solar farms, offshore wind                                                                                  | 1                            |
|     | <b>Module 3: Environmental Impact and Pollution Control</b>                                                                                                 | <b>6</b>                     |
| 3.1 | Pollution Types: Air, water, and soil pollution – sources and effects                                                                                       | 1                            |
| 3.2 | Pollution Control: Physical, chemical, and biological treatment methods                                                                                     | 1                            |
| 3.3 | Climate Change: GHGs, carbon footprint, international agreements (Kyoto, Paris)                                                                             | 1                            |
| 3.4 | Waste Management: Solid, liquid, biomedical, hazardous – 3Rs, waste-to-energy, Environmental regulations                                                    | 1                            |
| 3.5 | Carbon Neutrality: National missions, zero-emission policies, corporate initiatives                                                                         | 1                            |
| 3.6 | Circular Economy: Waste elimination                                                                                                                         | 1                            |
|     | <b>Module 4: Sustainability and Green Practices</b>                                                                                                         | <b>6</b>                     |
| 4.1 | Sustainable Development: Principles, SDGs, resource efficiency                                                                                              | 1                            |
| 4.2 | Green Buildings: Concepts, features, materials, passive design, renewables integration, green certifications                                                | 1                            |

|                                                                                                                               |                                                                       |                 |
|-------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|-----------------|
| 4.3                                                                                                                           | Carbon Credits: Earning, trading, CDM, voluntary carbon markets       | 1               |
| 4.4                                                                                                                           | Carbon Pricing and Subsidies: Internal pricing, UJALA, PM-KUSUM, FAME | 1               |
| 4.5                                                                                                                           | Life Cycle Assessment (LCA): Phases, case studies                     | 1               |
| 4.6                                                                                                                           | Smart Cities and Resilience: Urban planning                           | 1               |
| Students shall present a seminar based on case studies of Life Cycle Assessment (LCA) conducted on a product of their choice. |                                                                       |                 |
|                                                                                                                               | Total Hours                                                           | <b>24 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1)

1. List the major renewable and non-renewable energy sources with suitable examples.
2. Explain the significance of energy conservation in the industrial and domestic sectors.
3. Describe the importance of energy conservation in the context of the global and Indian energy scenario.

#### Course Outcome 2 (CO 2)

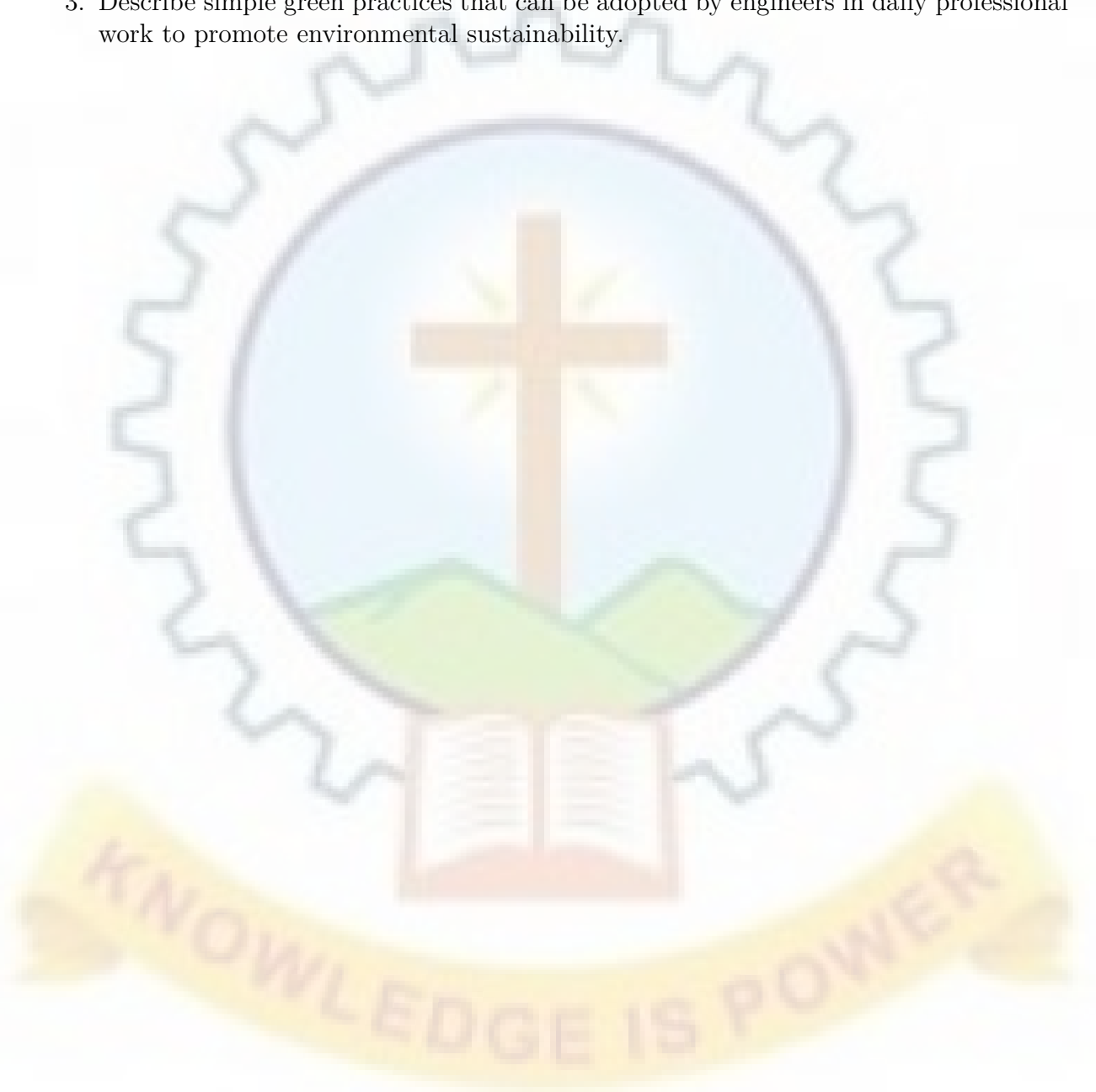
1. Describe the working principle of solar photovoltaic and solar thermal systems.
2. Compare wind energy and small hydropower systems based on availability, reliability, and applications.
3. Explain the role of energy storage and smart grid integration in ensuring renewable energy reliability.

#### Course Outcome 3 (CO 3)

1. Identify major sources of air and water pollution in urban areas.
2. Explain the role of battery storage and smart grid integration in enhancing the efficiency of renewable energy systems.
3. Apply the concept of 3Rs to develop a basic household or institutional waste management plan.

**Course Outcome 4 (CO 4)**

1. Describe the concept of sustainable development and its connection with UN Sustainable Development Goals (SDGs).
2. Explain the basic features of green buildings and the benefits of green certification.
3. Describe simple green practices that can be adopted by engineers in daily professional work to promote environmental sustainability.





MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

THIRD SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2025

**Course Code: B24MC2T05**

**Course Name: ENERGY CONSERVATION AND ENVIRONMENTAL SUSTAINABILITY**

Max. Marks: 50

Duration: 2 hours

**PART A**

**Answer all questions. Each question carries 3 marks.**

1. List any three renewable energy sources with one example each.
2. Explain the concept of net metering in decentralized energy generation.
3. What are the major sources of air pollution in urban areas?
4. Describe any two strategies for promoting sustainability in everyday engineering practices.

**PART B**

**Answer any one question from each module**

5. (a) Classify energy resources with examples. (4 marks)  
(b) Explain the significance of energy conservation in the Indian context. (5 marks)

**OR**

6. (a) Describe energy auditing and mention any two efficiency improvement techniques. (5 marks)  
(b) What is the role of energy-efficient buildings in smart city development? (4 marks)

7. (a) Explain the working principle of wind turbines with a neat diagram. (5 marks)  
(b) Describe any two advanced renewable energy technologies. (4 marks)

**OR**

8. (a) Discuss the types and role of energy storage systems in renewable energy. (5 marks)  
(b) Explain the concept of smart grid integration. (4 marks)
9. (a) What are the major environmental impacts of energy consumption? (4 marks)  
(b) Explain physical, chemical, and biological methods of water pollution control. (6 marks)

**OR**

10. (a) Describe the working of waste-to-energy technologies. (5 marks)  
(b) List and briefly explain any two environmental regulations in India. (5 marks)
11. (a) Define sustainable development and explain its principles. (4 marks)  
(b) What are carbon credits and how do they promote sustainability? (6 marks)

**OR**

12. (a) Explain the key phases of Life Cycle Assessment (LCA). (5 marks)  
(b) What is the importance of green buildings and certification systems in achieving sustainable urban infrastructure? (5 marks)

| B24ECM31 | ELECTRONIC<br>CIRCUITS<br>(Minor) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|----------|-----------------------------------|---|---|---|---|--------|-------------------------|
|          |                                   | 3 | 1 | 0 | 5 | 4      | 2024                    |

### Preamble

This course aims to develop the skill for the design of various analog circuits.

### Prerequisites

B24ES1T02 : Basics of Electrical and Electronics Engineering.

B24ES1T08 : Fundamentals of Electronics Engineering.

### Course Outcomes

After the completion of the course the student will be able to:

|      |                                                                                                                   |
|------|-------------------------------------------------------------------------------------------------------------------|
| CO 1 | Realize simple circuits using diodes, resistors and capacitors. [Understand , Apply]                              |
| CO 2 | Design amplifier and oscillator circuits. [Apply, Analyze]                                                        |
| CO 3 | Design power supplies, D/A and A/D converters for various applications. [Apply, Analyze]                          |
| CO 4 | Design and analyze circuits using opertational amplifiers. [Apply, Analyze]                                       |
| CO 5 | Design and analyze circuits using Digital to Analog converters and Analog to Digital Converters. [Apply, Analyze] |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 3    |      |      |      |      |      |      |      |       | 2     |
| CO 2 | 3    | 3    |      |      |      |      |      |      |      |       | 2     |
| CO 3 | 3    | 3    |      |      |      |      |      |      |      |       | 2     |
| CO 4 | 3    | 3    |      |      |      |      |      |      |      |       | 2     |
| CO 5 | 3    | 3    |      |      |      |      |      |      |      |       | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 30                    | 30              | 30                                 |
| Understand       | 40                    | 40              | 40                                 |
| Apply            | 30                    | 30              | 30                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Wave shaping circuits:** Sinusoidal and non-sinusoidal wave shapes, Principle and working of RC differentiating and integrating circuits, Clipping circuits - Positive, negative and biased clipper. Clamping circuits - Positive, negative and biased clamper.

**Transistor biasing:** Introduction, operating point, concept of load line, thermal stability (derivation not required), fixed bias, self bias, voltage divider bias.

### MODULE 2

**MOSFET:** Structure, Enhancement and depletion types, principle of operation and characteristics

**Amplifiers:** Classification of amplifiers, RC coupled amplifier-design and working, voltage gain and frequency response. Multistage amplifiers - effect of cascading on gain and bandwidth.

Feedback in amplifiers-Effect of negative feedback on amplifiers. MOSFET Amplifiers- Circuit diagram, design and working of common source MOSFET amplifier.

### MODULE 3

**Oscillators:** Classification, criterion for oscillation, Wien bridge oscillator, Hartley and Crystal oscillator. (design equations and working of the circuits;analysis not required).

**Regulated Power supplies:** Review of simple zener voltage regulator, series voltage regulator, 3 pin regulators-78XX and 79XX, DC to DC conversion, Circuit/block diagram and working of SMPS.

### MODULE 4

**Operational Amplifiers:** Characteristics of Op-Amps(gain, bandwidth, slewrate, CMRR, offset voltage, offset current), comparison of ideal and practical op-amp(IC741), applications of op-amp-scale changer, sign changer, adder/summing amplifier, subtractor, integrator, differentiator, comparator, instrumentation amplifier.

### MODULE 5

**Integrated circuits:**D/A and A/D converters - important specifications, Sample and hold circuit, R-2R ladder type D/A converters. Flash and sigma-delta type A/D Converters.

Circuit diagram and working of Timer IC555, astable and monostable multivibrators using IC555

**Text Books**

1. Robert Boylestad and L Nashelsky, Electronic Devices and Circuit Theory, Pearson, 2015.
2. Salivahanan S. and V. S. K. Bhaaskaran, Linear Integrated Circuits, Tata McGraw Hill, 2008

**Reference Books**

1. David A Bell, Electronic Devices and Circuits, Oxford University Press, 2008.
2. Neamen D., Electronic Circuits, Analysis and Design, 3/e, TMH, 2007
3. Millman J. and C. Halkias, Integrated Electronics, 2/e, McGraw-Hill, 2010.
4. Op-Amp and Linear Integrated Circuits, Ramakant A Gayakwad, PHI, 2000.
5. K. Gopakumar, Design and Analysis of Electronic Circuits, Phasor Books, Kollam, 2013.



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                      | No of Lecture/Tutorial Hours |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                            | <b>9</b>                     |
| 1.1 | Sinusoidal and non-sinusoidal wave shape.                                                                                                  | 1                            |
| 1.2 | Principle and working of RC differentiating and integrating circuits.                                                                      | 2                            |
| 1.3 | Clipping circuits - Positive, negative and biased clipper.                                                                                 | 2                            |
| 1.4 | Clamping circuits - Positive, negative and biased clamper.                                                                                 | 2                            |
| 1.5 | Introduction, operating point, concept of load line, thermal stability, fixed bias, self bias, voltage divider bias..                      | 2                            |
|     | <b>Module 2</b>                                                                                                                            | <b>9</b>                     |
| 2.1 | MOSFET-Structure, Enhancement and depletion types, principle of operation and characteristics                                              | 2                            |
| 2.2 | Amplifiers-Classification of amplifiers, RC coupled amplifier-design and working, voltage gain and frequency response.                     | 3                            |
| 2.3 | Multistage amplifiers - effect of cascading on gain and bandwidth.                                                                         | 1                            |
| 2.4 | Feedback in amplifiers-Effect of negative feedback on amplifiers.                                                                          | 1                            |
| 2.5 | MOSFET Amplifiers-Circuit diagram, design and working of common source MOSFET amplifier.                                                   | 2                            |
|     | <b>Module 3</b>                                                                                                                            | <b>9</b>                     |
| 3.1 | Oscillators - Classification, criterion for oscillation.                                                                                   | 1                            |
| 3.2 | Wien bridge oscillator, Hartley and Crystal oscillator.                                                                                    | 3                            |
| 3.3 | Regulated Power Supplies-Review of simple zener voltage regulator, series voltage regulator.                                               | 3                            |
| 3.4 | 3 pin regulators-78XX and 79XX,                                                                                                            | 1                            |
| 3.5 | DC to DC conversion, Circuit/block diagram and working of SMPS.                                                                            | 1                            |
|     | <b>Module 4</b>                                                                                                                            | <b>10</b>                    |
| 4.1 | Operational Amplifiers                                                                                                                     | 2                            |
| 4.2 | Characteristics of Op-Amps(gain,bandwidth,slewrate,CMRR, offset voltage, offset current), comparison of ideal and practical op-amp(IC741). | 2                            |
| 4.3 | applications of op-amp-scale changer, sign changer, adder/-summing amplifier, subtractor, integrator, differentiator.                      | 3                            |
| 4.4 | Comparator, instrumentation amplifier.                                                                                                     | 3                            |
|     | <b>Module 5</b>                                                                                                                            | <b>8</b>                     |
| 5.1 | Integrated Circuits- D/A and A/D converters - important specifications, Sample and hold circuit.                                           | 1                            |
| 5.2 | R-2R ladder type D/A converters.                                                                                                           | 2                            |

|     |                                                                                               |                 |
|-----|-----------------------------------------------------------------------------------------------|-----------------|
| 5.3 | Flash and sigma-delta type A/D Converters.                                                    | 2               |
| 5.4 | Circuit diagram and working of Timer IC555, astable and monostable multivibrators using IC555 | 3               |
|     | <b>Total Hours</b>                                                                            | <b>45 Hours</b> |

### CO ASSESSMENT QUESTIONS

**Course Outcome 1 (CO 1): Realize simple circuits using diodes, resistors and capacitors**

1. For the given specification design a differentiator and integrator circuit.
2. For the given input waveform and circuit, draw the output waveform and transfer characteristics.
3. Explain the working of RC differentiator and integrator circuits and sketch the output waveform for different time periods.

**Course Outcome 2 (CO 2): Design amplifier and oscillator circuits.**

1. For the given transistor biasing circuit, determine the resistor values, biasing currents and voltages.
2. Explain the construction, principle of operation and characteristics of MOSFETs.
3. Design a RC coupled amplifier for a given gain.
4. Design a Hartley oscillator to generate a given frequency.

**Course Outcome 3 (CO 3): Design Power supplies, D/A and A/D converters for various applications.**

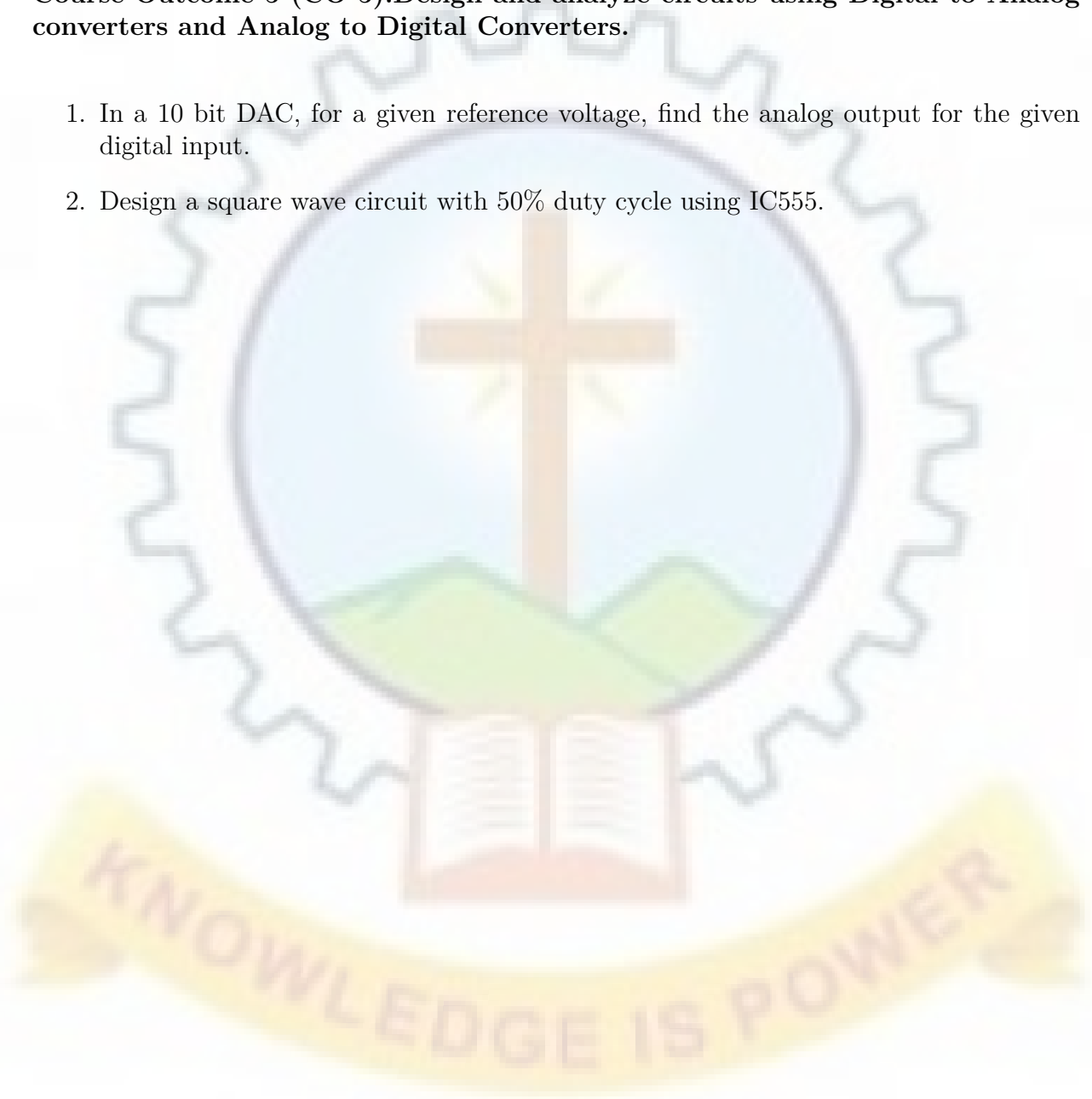
1. Design a series voltage regulator.
2. For the regulator circuit, find the output voltage and current through the zener diode.
3. In a 10 bit DAC, for a given reference voltage, find the analog output for the given digital input.

**Course Outcome 4 (CO 4): Design circuits using operational amplifiers for various applications**

1. For the given difference amplifier, find the output voltage.
2. Derive the expression for frequency of oscillation of Wien bridge oscillator using op-amp.
3. Realize a summing amplifier to obtain a given output voltage.

**Course Outcome 5 (CO 5): Design and analyze circuits using Digital to Analog converters and Analog to Digital Converters.**

1. In a 10 bit DAC, for a given reference voltage, find the analog output for the given digital input.
2. Design a square wave circuit with 50% duty cycle using IC555.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**THIRD SEMESTER B TECH DEGREE (MINOR) EXAMINATION, DECEMBER  
2025**

**Course Code: B24ECM31**

**Course Name: ELECTRONIC CIRCUITS**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

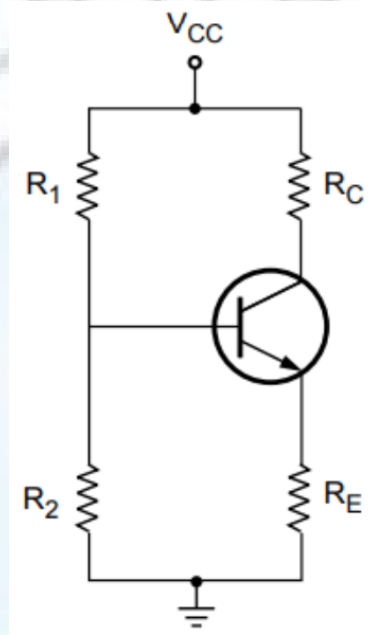
1. Design a negative biased clamper circuit and draw the transfer characteristics.
2. Give the importance of biasing in transistors. Mention significance of operating points.
3. What is line regulation and load regulation in the context of a voltage regulator? Explain with equation for percentage of regulation.
4. Compare the features of FET with BJT.
5. What is the effect of cascading in gain and bandwidth of amplifier?
6. Discuss about simple zener shunt voltage regulator.
7. Realize a circuit to obtain  $V_O = -2V_1 + 3V_2 + 4V_3$  using operational amplifier. Use minimum value of resistance as  $10\text{ K}\Omega$ .
8. Design a monostable multivibrator using IC555 timer for a pulse period of 1ms.
9. Describe the working of a Flashtype A/D Converter, with example.
10. Define i) Slew rate ii) CMRR iii) Offset voltage and current

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Define a differentiator circuit for a square wave signal with  $V_{pp} = 10$  and frequency  $10\text{KHz}$  (5)
- b) Consider a self biasing circuit shown in figure below with  $V_{cc} = 20\text{V}$ ,  $R_c = 1.5\text{K}\Omega$ , which is operated at Q-point ( $V_{cc} = 8\text{V}$ ,  $I_C = 4\text{mA}$ , if  $h_{fe} = 100$ , find  $R_1$ ,  $R_2$ , and  $R_e$ . Assume  $V_{BE} = 0.7\text{V}$  (9)



12. Explain the working of a RC differentiator circuit for a square wave input with period  $T$ . Sketch its output waveform for  $RC > T$ ,  $RC < T$  and  $RC = T$ . (14)

**Module II**

13. a) With neat sketches, explain the construction, principle of operation and characteristics of a N-Channel enhancement MOSFET. (9)
- b) Draw the circuit of an RC coupled amplifier and explain the functions of each element. (5)
14. a) Draw the circuit of a common source amplifier using MOSFET. Derive the expressions for voltage gain and input resistance. (9)
- b) Sketch the frequency response of a RC coupled amplifier write the reasons for gain reduction in both the ends. (5)

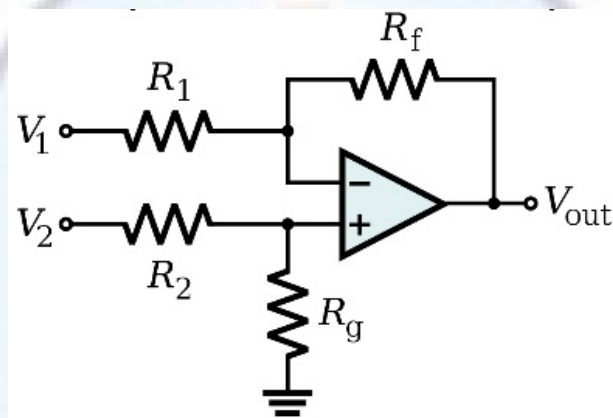
**Module III**

15. a) Design a Hartley oscillator to generate a frequency of  $150\text{KHz}$  (5)
- b) Draw the circuit of a series voltage regulator. Explain its working when the input voltage and the load current vary. Design a circuit to deliver  $5\text{V}$ ,  $100\text{mA}$  maximum load current. (9)

16. a) With neat diagram and equations explain the working of a Wien bridge oscillator using BJT. (7)
- b) Derive the expression for the frequency of oscillation of Wien bridge oscillator using BJT. (7)

#### Module IV

17. a) With circuit, relevant equations and waveforms, explain the working of a Schmitt trigger using op-amp (9)
- b) The difference amplifier shown in the figure have  $R_1 = R_2 = 5K\Omega$ ,  $R_f = 10K\Omega$ ,  $R_g = 1K\Omega$ . Calculate the output voltage (5)



18. a) With the circuits and equations show that an op-amp can act as an integrator, differentiator, adder and subtractor. (9)
- b) what do you mean by differential amplifier? With neat sketches explain the working of an open loop op-amp differential amplifier. (5)

#### Module V

19. a) Explain the working of an R-2R ladder type DAC. In a 10-bit DAC, reference voltage is given as 15V. Find analog output for digital input of 1011011001. (10)
- b) With neat diagram explain the working of IC555 timer. (4)
20. a) Design an astable multivibrator using IC555 timer for a frequency of 1KHz and a duty cycle of 70%. Assume  $C = 0.1\mu F$  (7)
- b) Draw and explain sample and hold circuit and explain the necessity of this circuit in ADC. (7)



| <b>B24ECM32</b> | <b>ANALOG COMMUNICATION<br/>(Minor)</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF INTRODUCTION</b> |
|-----------------|-----------------------------------------|----------|----------|----------|----------|---------------|-----------------------------|
|                 |                                         | 3        | 1        | 0        | 5        |               |                             |

**Preamble**

The course is designed to provide a comprehensive understanding of analog modulation techniques and their practical implementations. It focuses on two primary objectives: first, to explore the principles and applications of two key analog modulation schemes—amplitude modulation (AM) and frequency modulation (FM)—and second, to examine the design and functionality of transmitter and receiver systems employed in AM and FM communication. Through this study, students will gain insight into the foundational concepts of analog communication and the technical frameworks that enable effective signal transmission and reception.

**Prerequisites**

Nil

**Course Outcomes**

After the completion of the course the student will be able to:

|             |                                                                                                                       |
|-------------|-----------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Describe the key components of a communication system and their roles in the process [Understand].                    |
| <b>CO 2</b> | Identify different sources of noise in a communication system and explain how they impact signal quality.[Understand] |
| <b>CO 3</b> | Demonstrate how amplitude modulation and its variants are implemented for a sinusoidal message signal.[Apply]         |
| <b>CO 4</b> | Illustrate the application of frequency modulation and its variants to a sinusoidal message signal.[Apply]            |
| <b>CO 5</b> | Outline the different transmitter and receiver systems used in AM and FM, and compare their features.[Understand]     |

**Mapping of Course Outcomes With Program Outcomes**

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 3    |      |      |      |      |      |      |      |       |       |
| CO 2 | 3    | 3    |      |      |      |      |      |      |      |       |       |
| CO 3 | 3    | 3    |      |      |      |      |      |      |      |       |       |
| CO 4 | 3    | 3    |      |      |      |      |      |      |      |       |       |
| CO 5 | 3    | 3    |      |      |      |      |      |      |      |       |       |

### Assessment Pattern

| Bloom's Category | Continuous Assessment Tests |                 | End Semester Examination (% Marks) |
|------------------|-----------------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)             | Test 2 (%Marks) |                                    |
| Remember         | 20                          | 20              | 20                                 |
| Understand       | 40                          | 40              | 40                                 |
| Apply            | 40                          | 40              | 40                                 |
| Analyse          |                             |                 |                                    |
| Evaluate         |                             |                 |                                    |
| Create           |                             |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## **CO Assessment Questions**

**Course Outcome 1 (CO1):** Explain various components of a communication system

1. What is the need of a modulator in a radio communication system.
2. What are the various frequency bands used in radio communication
3. Why base band communication is infeasible for terrestrial air transmission?

**Course Outcome 2 (CO2):** Discuss various sources of noise, and its effect in a communication system.

1. What is thermal noise?
2. Describe the noise voltage generated across resistor.
3. Why is it that noise voltage cannot be used as a source for power?

**Course Outcome 3 (CO3):** Explain amplitude modulation and its variants for a sinusoidal message.

1. Write down the equation for an AM wave for a sinusoidal message.
2. What is the significance of modulation index?
3. Describe envelope detector.

**Course Outcome 4 (CO4):** Explain frequency modulation and its variants for a sinusoidal message

1. How is practical bandwidth for an FM wave determined?
2. What are the value of frequency deviation, bandwidth for a typical FM station?
3. What is PLL?

**Course Outcome 5 (CO5):** List and compare various transmitter and receiver systems of AM and FM

1. Draw the block diagram of a super heterodyne receiver.
2. How is adjacent channel rejection achieved in superhet? How is image rejection achieved in a superhet?
3. Explain the working principle of one FM generator, and one FM demodulator.

## **Syllabus**

### **MODULE I**

Introduction, Elements of communication systems, Examples of analog communication systems, Frequency bands, Need for modulation. Noise in communication system, Definitions of Thermal noise (white noise), Various types of noise – Shot noise, Partition noise, Flicker noise, Burst noise, (No analysis required) Signal to noise ratio, Noise factor, Noise temperature, Narrow band noise.

### **MODULE II**

Brief overview of signals and systems – Signals, Classification of signals, Energy and power of signals, Basic signal operations, Impulse function, Properties of impulse function, Convolution, LTI system, Fourier Transform, Basic properties, Using Fourier transform to study LTI system.

### **MODULE III**

Amplitude modulation (AM), Double-side band suppressed carrier (DSB-SC) modulation Single sideband modulation (SSB) – spectrum, power, efficiency of all the three variants. (Study of only tone modulation in DSB-SC, AM, and SSB.) Amplitude-modulator implementations – switching modulator, balanced modulator. AM demodulators – Coherent demodulator. Envelope detector.

### **MODULE IV**

Frequency modulation – modulation index, frequency deviation, average power, spectrum of tone modulated FM. Heuristics for bandwidth of FM. Narrow band FM and wide-band FM. FM generation: Varactor diode modulator, Armstrong's method. FM demodulation – slope detection, PLL demodulator.

### **MODULE V**

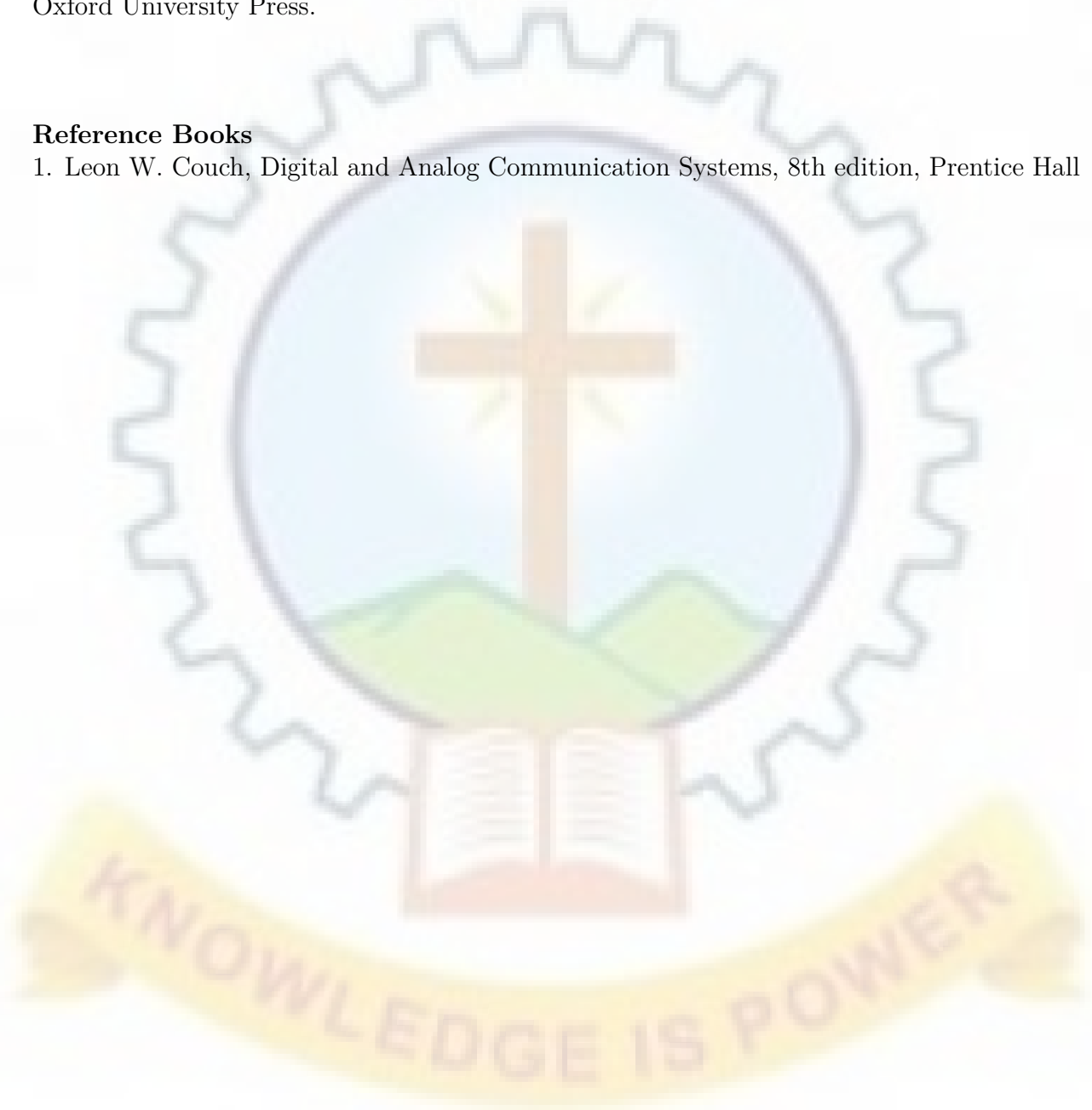
Super heterodyne receiver, Principle of Carrier synchronization using PLL, NTSC Television broadcasting.

**Text Books**

1. Kennedy, Davis, “Electronic Communication Systems,” 4th Edition, Tata McGra
2. Wayne Tomasi, “Electronic Communication Systems – Fundamentals through Advanced,” 5th edition, Pearson.
3. B. P. Lathi, Zhi Ding, Modern Digital and Analog Communication Systems, 4th edition, Oxford University Press.

**Reference Books**

1. Leon W. Couch, Digital and Analog Communication Systems, 8th edition, Prentice Hall



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                                                                                                 | No of Lecture/Tutorial Hours |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module I</b>                                                                                                                                                                                                                       | <b>8</b>                     |
| 1.1 | Introduction, Elements of communication systems, Examples of analog communication systems, Frequency bands, Need for modulation                                                                                                       | 3                            |
| 1.2 | Noise in communication system, Definitions of Thermal noise (white noise), Shot noise, Partition noise, Flicker noise, Burst noise, (No analysis required) Signal to noise ratio, Noise factor, Noise temperature, Narrow band noise. | 5                            |
|     | <b>Module II</b>                                                                                                                                                                                                                      | <b>13</b>                    |
| 2.1 | Brief Overview of Signals and Systems: Signals, Classification of signals, Energy and power of signals, Basic signal operations                                                                                                       | 4                            |
| 2.2 | Impulse function, Properties of impulse function, Convolution,                                                                                                                                                                        | 2                            |
| 2.3 | Definition of Linear time-invariant system. Input-output relation of LTI system                                                                                                                                                       | 2                            |
| 2.4 | Definition of Fourier Transforms, Some Properties of Fourier Transform – Linearity, Time-shift, Modulation theorem, Parsevals theorem. Using Fourier Transform to study LTI systems.                                                  | 5                            |
|     | <b>Module III</b>                                                                                                                                                                                                                     | <b>9</b>                     |
| 3.1 | Amplitude modulation (AM) – modulation index, spectrum, power, efficiency.                                                                                                                                                            | 2                            |
| 3.2 | Double-side band suppressed carrier (DSB-SC) modulation – spectrum, power, efficiency.                                                                                                                                                | 1                            |
| 3.3 | Single sideband modulation (SSB) – spectrum, power, efficiency. (Study of only tone modulation in DSB-SC, AM, and SSB.)                                                                                                               | 1                            |
| 3.4 | Amplitude-modulator implementations – switching modulator, balanced modulator (at block diagram level).                                                                                                                               | 2                            |
| 3.5 | AM demodulators – Coherent demodulator. Envelope detector.                                                                                                                                                                            | 3                            |
|     | <b>Module 4</b>                                                                                                                                                                                                                       | <b>9</b>                     |
| 4.1 | Frequency modulation – modulation index, frequency deviation, average power, spectrum of tone modulated FM                                                                                                                            | 4                            |
| 4.2 | Heuristics for bandwidth of FM. Narrow band FM and wide-band FM.                                                                                                                                                                      | 1                            |
| 4.3 | FM generation: Varactor diode modulator, Armstrongs method. FM demodulation – slope detection, PLL demodulator.                                                                                                                       | 4                            |
|     | <b>Module V</b>                                                                                                                                                                                                                       | <b>6</b>                     |



|     |                                                                   |   |
|-----|-------------------------------------------------------------------|---|
| 5.1 | Receivers for AM/FM: Super heterodyne receiver (block diagram)    | 1 |
| 5.2 | Adjacent channel selectivity, Image rejection, Double conversion. | 2 |
| 5.3 | Carrier Synchronization using PLL                                 | 1 |
| 5.4 | NTSC Television broadcasting using AM, FM radio broadcasting.     | 2 |



**Model Question Paper**

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**THIRD SEMESTER BTECH DEGREE (MINOR) EXAMINATION  
DECEMBER 2024**

**Course Code: B24ECM32**

**Course Name: ANALOG COMMUNICATION**

Max. Marks: 100

Duration: 3 Hours

**PART A**

*Answer all questions, each carries 3 marks*

1. Explain the need for modulation. (3)
2. A receiver connected to an antenna whose resistance is 50 ohm has an equivalent noise resistance of 30 ohm. Calculate receiver noise figure in decibels & its equivalent noise temperature? (3)
3. Plot the signal  $x(t) = u(t + 1) + 2u(t) - u(t - 3)$ . (3)
4. State Parseval's theorem for DTFT. What is its significance? (3)
5. Define amplitude modulation? Give the frequency spectrum for AM wave? (3)
6. Derive the expression for total power of AM wave? (3)
7. Explain the following terms: (a) Modulation index (b) Instantaneous frequency deviation. (3)
8. Compare AM & FM systems. (3)
9. What are the advantages that the super heterodyne receiver has over the receivers? Are there any disadvantages? (3)
10. Give the limitations of NTSC systems? (3)

**PART B**

*Answer any one full question from each module, each carries 14 marks.*

**Module I**

11. (a) Explain the following: (i) Thermal noise (ii) Flicker noise. (6)  
(b) Explain the elements of communication systems in detail? (8)

OR

12. (a) Define the signal-to-noise ratio and noise and noise figure of a receiver? How is noise temperature related to noise figure? (8)  
(b) List the basic functions of a radio transmitter & the corresponding functions of the receiver? (6)

**Module II**

13. (a) Distinguish between energy & power signals. Give an example for each category? (7)  
(b) State and prove the linearity and time-shifting property of Fourier Transform? (7)

OR

14. (a) Check whether the systems are linear & stable: (i)  $y(t) = e^{x(t)}$  (ii)  $y[n] = x[n - 1]$ . (6)  
(b) Find convolution of signal  $x[n] = [1, -1, 1, 1]$  with itself? Distinguish between causal & non-causal systems with suitable examples? (8)

**Module III**

15. (a) Derive the expression of total power in SSB wave? (7)  
(b) Describe the AM demodulation using envelope detector? (7)

OR

16. (a) Describe the DSB-SC wave generation process using balanced modulation. (9)  
(b) Give the spectrum of SSB & DSB-SC waves? Make a comparison of bandwidth requirements. (5)

**Module IV**

17. (a) Explain the direct method of generating FM signal using a varactor diode? (7)  
(b) Explain frequency modulation and its average power? (7)

OR

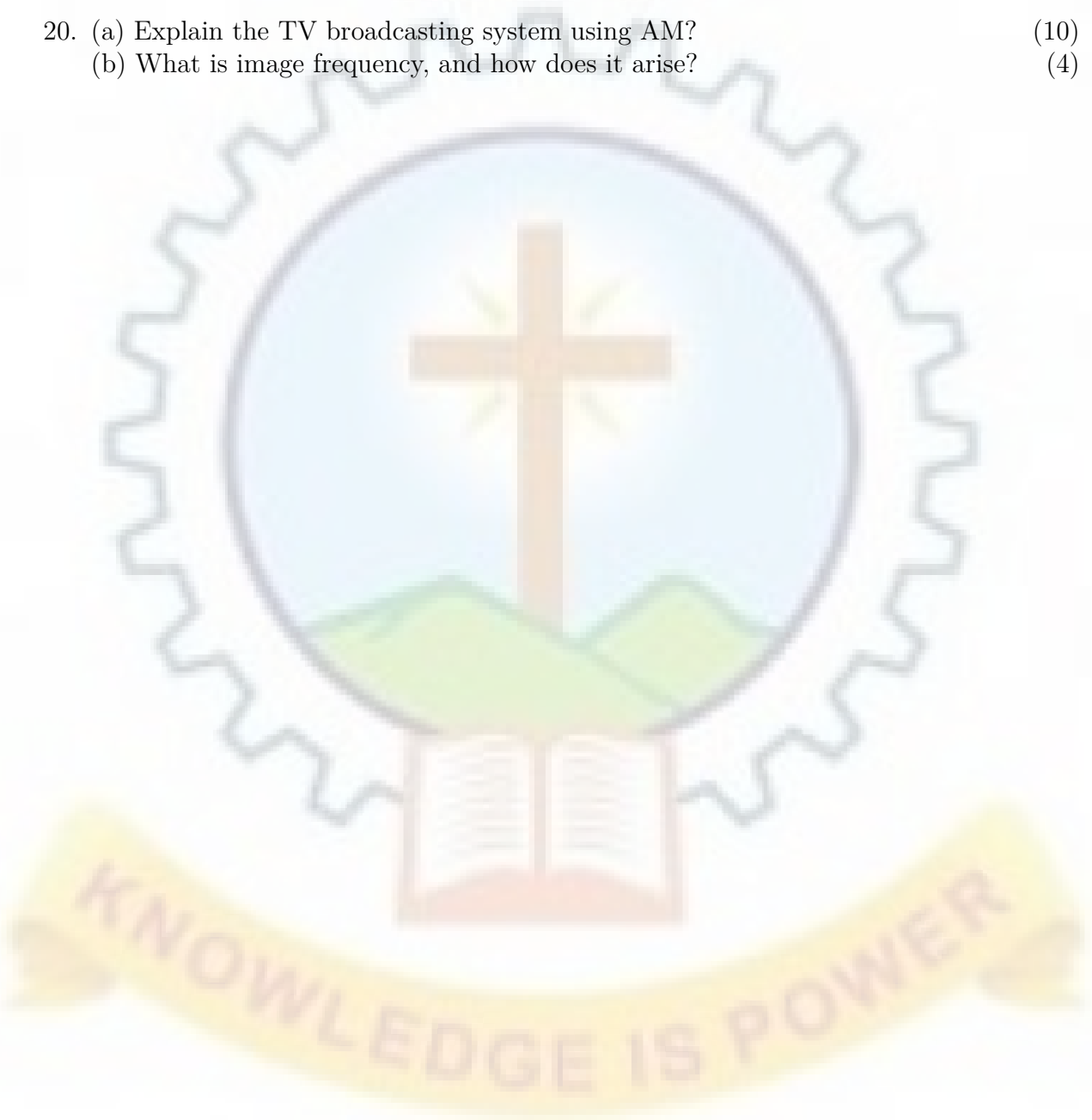
18. (a) Explain with relevant mathematical expressions, the demodulation of FM signal using PLL? (10)  
(b) Give the spectrum of tone modulated FM? (4)

**Module V**

19. (a) Explain the super heterodyne receiver with a detailed block diagram? (10)  
(b) Explain how the use of RF amplifier improves the NR of a super heterodyne receiver? (4)

OR

20. (a) Explain the TV broadcasting system using AM? (10)  
(b) What is image frequency, and how does it arise? (4)



| B24ECM33 | INTRODUCTION<br>TO SIGNALS AND<br>SYSTEMS<br>(Minor) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|----------|------------------------------------------------------|---|---|---|---|--------|-------------------------|
|          |                                                      | 3 | 1 | 0 | 5 |        |                         |

### Preamble

This course aims to provides the foundational principles for analyzing, processing, and understanding signals and the systems that manipulate them, essential for modern engineering applications.

### Prerequisites

Nil

### Course Outcomes

After the completion of the course the student will be able to:

|             |                                                                                                                                                                                                                                        |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Classify and represent continuous-time and discrete-time signals and systems, and perform basic signal operations. [Understand , Apply]                                                                                                |
| <b>CO 2</b> | Model and analyze continuous-time and discrete-time systems using differential and difference equations, focusing on stability and causality. [Apply, Analyze]                                                                         |
| <b>CO 3</b> | Apply Fourier series, Fourier transforms, and Laplace transforms to analyze continuous-time signals in the frequency domain, including sampling and aliasing effects. [Apply, Analyze]                                                 |
| <b>CO 4</b> | Represent and analyze discrete-time signals using Discrete Time Fourier Series (DTFS) and Discrete Time Fourier Transform (DTFT) along with their properties for spectral and frequency-domain analysis.[Apply, Analyze]               |
| <b>CO 5</b> | Analyze discrete-time signals and LTI systems using Z-transform, DTFT, and their properties, including system transfer functions, magnitude, and phase responses, for comprehensive frequency-domain characterization.[Apply, Analyze] |

### Mapping of Course Outcomes With Program Outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 3    | 2    | 2    | 1    |      |      |      |      |       | 1     |
| <b>CO 2</b> | 3    | 3    | 3    | 2    | 2    |      |      |      |      |       | 1     |
| <b>CO 3</b> | 3    | 3    | 2    | 2    | 2    |      |      |      |      |       | 1     |
| <b>CO 4</b> | 3    | 3    | 3    | 2    | 2    |      |      |      |      |       | 1     |
| <b>CO 5</b> | 3    | 3    | 3    | 3    | 2    |      |      |      |      |       | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 30                    | 30                 | 30                                    |
| Understand       | 40                    | 40                 | 40                                    |
| Apply            | 30                    | 30                 | 30                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Quiz/Course project         | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.



## SYLLABUS

### MODULE 1

**Basics of Signals and Systems:** Elementary Signals, Classification and representation of continuous time and discrete time signals, Signal operations.- Continuous time and discrete time systems - Classification, Properties.

### MODULE 2

**System Representation and Analysis :** Representation of systems: Differential equation representation of continuous time systems, Difference equation representation of discrete systems. Discrete time LTI systems and linear convolution,- Stability and causality of LTI systems.

### MODULE 3

**Frequency Domain Representation of continuous time signals:** . Frequency domain representation of continuous time signals-Continuous time Fourier series Continuous time fourier transform,-Laplace Transform (Basics only),Sampling and Aliasing.

### MODULE 4

**Frequency domain representation of discrete time signals** -Discrete time fourier series and its properties.- Discrete time fourier transform (DTFT) and its properties

### MODULE 5

**Discrete-Time LTI System Analysis:** Z transform, ROC, Inverse transform, properties, Unilateral Z transform, Relation between DTFT and Z transform, Analysis of discrete time LTI systems using Z transforms and DTFT, Transfer function, Magnitude and phase response

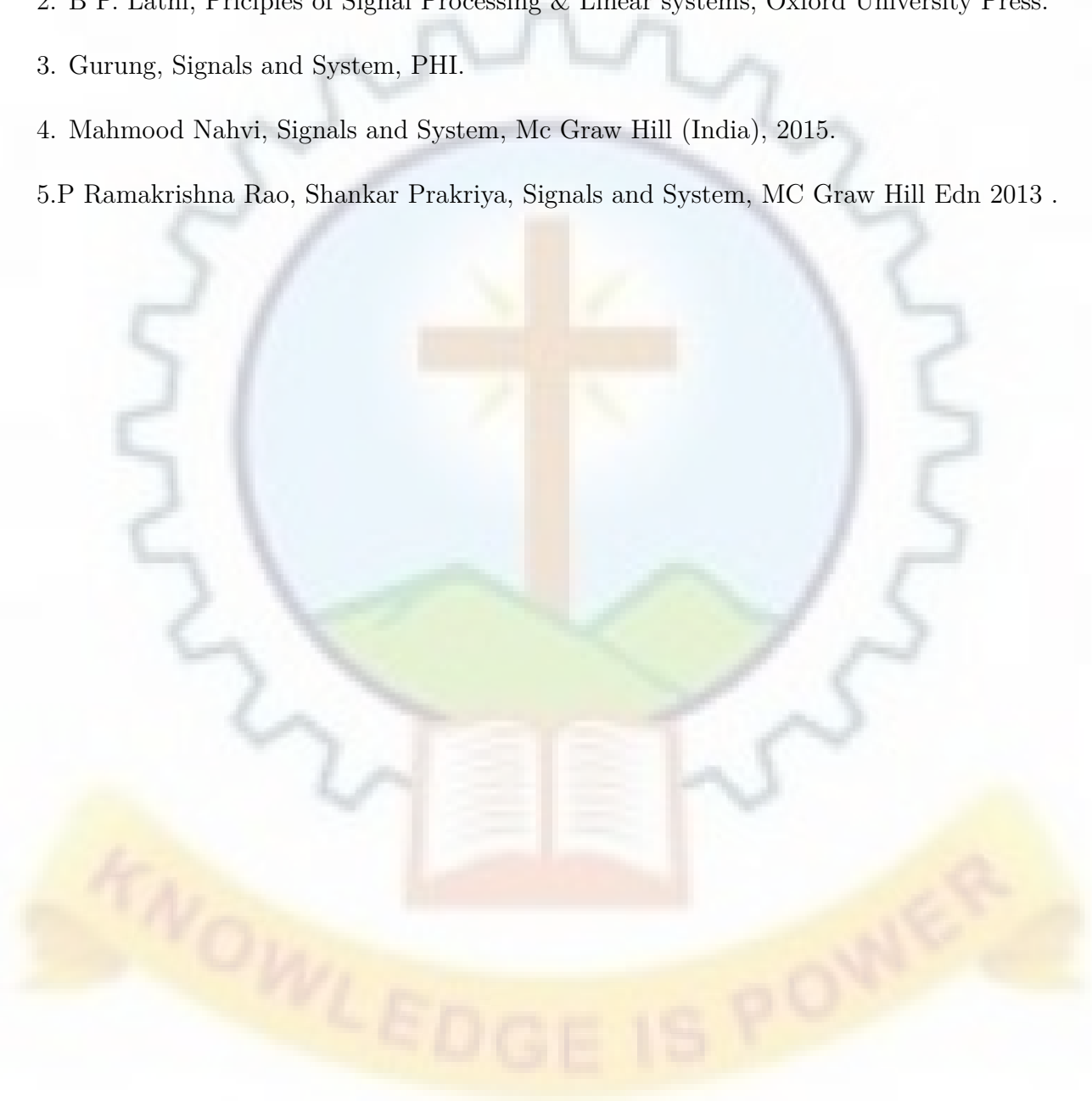
### Text Books

1. Signals and Systems: Oppenheim Alan- V- Willsky Alan. S- Pearson Edn

2. 2. Communication Systems: Haykin Simon- John Wiley

**Reference Books**

1. Anand Kumar, Signals and Systems, PHI, 3/e, 2013.
2. B P. Lathi, Principles of Signal Processing & Linear systems, Oxford University Press.
3. Gurung, Signals and System, PHI.
4. Mahmood Nahvi, Signals and System, Mc Graw Hill (India), 2015.
5. P Ramakrishna Rao, Shankar Prakriya, Signals and System, MC Graw Hill Edn 2013 .



**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                   | <b>No of Lecture/Tutorial Hours</b> |
|-----------|--------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                | <b>9</b>                            |
| 1.1       | Elementary Signals                                                             | 1                                   |
| 1.2       | Classification and representation of continuous time and discrete time signals | 1                                   |
| 1.3       | Signal operations                                                              | 1                                   |
| 1.4       | Continuous time systems-Classification, Properties                             | 3                                   |
| 1.5       | Discrete time systems- Classification, Properties                              | 3                                   |
|           | <b>Module 2</b>                                                                | <b>9</b>                            |
| 2.1       | Differential equation representation of continuous time systems                | 2                                   |
| 2.2       | Difference equation representation of discrete systems                         | 2                                   |
| 2.3       | Discrete time LTI systems and linear convolution                               | 2                                   |
| 2.4       | Stability of LTI systems                                                       | 2                                   |
| 2.5       | Causality of LTI systems                                                       | 1                                   |
|           | <b>Module 3</b>                                                                | <b>9</b>                            |
| 3.1       | Frequency domain representation of continuous time signals                     | 2                                   |
| 3.2       | Continuous time Fourier series and Continuous time fourier transform           | 2                                   |
| 3.3       | Laplace Transform (Basics only)                                                | 2                                   |
| 3.4       | Sampling and Aliasing                                                          | 3                                   |
|           | <b>Module 4</b>                                                                | <b>8</b>                            |
| 4.1       | Discrete time fourier series and its properties                                | 4                                   |
| 4.2       | Discrete time fourier transform (DTFT) and its properties                      | 4                                   |
|           | <b>Module 5</b>                                                                | <b>10</b>                           |
| 5.1       | Z transform, ROC                                                               | 2                                   |
| 5.2       | Inverse transform, properties                                                  | 2                                   |
| 5.3       | Unilateral Z transform, Relation between DTFT and Z transform                  | 2                                   |
| 5.4       | Analysis of discrete time LTI systems using Z transforms and DTFT              | 2                                   |
| 5.5       | Transfer function, Magnitude and phase response                                | 2                                   |
|           | <b>Total Hours</b>                                                             | <b>45 Hours</b>                     |

## CO ASSESSMENT QUESTIONS

### Course Outcome 1 (CO 1):

- (a) Define and sketch the following elementary signals: i. Unit Step Signal ii. Unit Impulse Signal iii. Ramp Signal  
(b) Differentiate between continuous-time and discrete-time signals using suitable examples.
- (a) Define and explain the classification of continuous-time systems based on the following properties with examples: i. Linearity ii. Time Invariance iii. Causality

### Course Outcome 2 (CO 2):

- (a) Evaluate the discrete-time convolution sum with required plots for the following signal

$$y[n] = 3^n u[-n + 3] \cdot u[n - 2]$$

- (b) Determine whether the following system is static, time invariant, linear, and causal.  $x(t)$  and  $y(t)$  denote the input and output, respectively. Give an explanation for each.

$$y(t) = t^2 x(t) + x(t - 2)$$

### Course Outcome 3 (CO 3):

- (a) Derive the Fourier series representation of the periodic signal:

$$x(t) = \begin{cases} 1, & 0 \leq t < \frac{T}{2}, \\ -1, & \frac{T}{2} \leq t < T, \end{cases}$$

where  $T$  is the period.

- (b) Derive the Fourier transform of the signal:

$$x(t) = e^{-at} u(t),$$

where  $a > 0$  and  $u(t)$  is the unit step function.

- (c) A signal

$$x(t) = \cos(2000\pi t)$$

is sampled at a rate of 800 Hz. Determine whether aliasing occurs.

### Course Outcome 4 (CO 4):

- (a) A periodic signal  $x[n]$  is given as:

$$x[n] = \begin{cases} 1 & \text{if } n = 0, 1, 2, \\ 0 & \text{otherwise.} \end{cases}$$

Compute its Discrete-Time Fourier Series (DTFS) coefficients.

- (b) A signal  $x[n] = 0.5^n u[n]$  is given, where  $u[n]$  is the unit step function. Compute its Discrete-Time Fourier Transform (DTFT) and plot its magnitude spectrum.

**Course Outcome 5 (CO 5):**

- (a) Given the discrete-time signal

$$x[n] = (0.5)^n u[n],$$

where  $u[n]$  is the unit step function, find its Z-transform and determine the Region of Convergence (ROC). Discuss the significance of the ROC in the context of system stability.

- (b) Define the unilateral Z-transform and explain how it differs from the bilateral Z-transform. Calculate the unilateral Z-transform of the following signal:

$$x[n] = u[n] - u[n - 2],$$

where  $u[n]$  is the unit step function.

- (c) Given a system with impulse response

$$h[n] = (0.5)^n u[n],$$

where  $u[n]$  is the unit step function, find the system's transfer function using the Z-transform. Also, determine its frequency response using the Discrete-Time Fourier Transform (DTFT).

- (d) Find the transfer function of a discrete-time LTI system characterized by the difference equation:

$$y[n] - 0.5y[n - 1] = x[n],$$

and then analyze the system's stability based on the poles of the transfer function.

MODEL QUESTION PAPER

QP CODE:

Pages: 5

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

THIRD SEMESTER B TECH DEGREE MINOR EXAMINATION, DECEMBER  
2024

Course Code: B24ECM33

Course Name: INTRODUCTION TO SIGNALS AND SYSTEMS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks

- 1 What are the differences between continuous-time and discrete-time systems in terms of their classification and properties?
- 2 Define and explain periodic and aperiodic signals with examples in continuous and discrete time.
- 3 Explain the differential equation representation of continuous-time systems and the difference equation representation of discrete-time systems.
- 4 Discuss the concepts of stability and causality in Linear Time-Invariant (LTI) systems. How do they affect the system's performance?
- 5 Define the Continuous-Time Fourier Series (CTFS). Explain how it is used to represent periodic continuous-time signals in the frequency domain.
- 6 What is the process of sampling? Explain the concept of aliasing and how it can affect the representation of continuous-time signals when sampled at a lower rate than the Nyquist rate.
- 7 Discuss the symmetry properties of the DTFS. Prove that if  $x[n]$  is real and even, then its DTFS coefficients are real and even.
- 8 State and prove the time-shifting property of the Discrete-Time Fourier Transform (DTFT). How does the frequency spectrum of a signal change if the signal is shifted in time?



- 9 Explain the relationship between the Z-transform and DTFT. How does the Z-transform reduce to the DTFT when evaluated on the unit circle?
- 10 State and explain the time-shifting property of the Z-transform. Illustrate it with an example.

### PART B

**Answer any one question from each module. Each question carries 14 marks**

#### Module I

- 11 a) Explain the operations on continuous-time signals, such as time-shifting, time-scaling, and time-reversal. Provide examples and discuss their impact on the signal. (7)
- b) Explain the classification of discrete-time systems based on properties like linearity, time-invariance, causality, and stability. Provide examples and discuss their real-world applications. (7)
- 12 a) Discuss the concept of energy and power signals. Explain the mathematical conditions for a signal to be classified as energy or power, and provide examples for each. (7)
- b) Discuss the properties of continuous-time systems (linearity, time-invariance, causality, stability, memory). Provide examples of systems that exhibit these properties. (7)

#### Module II

- 13 a) Compute the convolution of the sequences:

$$x[n] = \{1, 2, 1\}, \quad h[n] = \{1, -1, 2\} \quad (7)$$

- b) Show that convolution is commutative for two discrete-time signals  $x[n]$  and  $h[n]$ . That is, prove that:

$$x[n] * h[n] = h[n] * x[n] \quad (7)$$

- 14 a) Prove that an LTI system is stable if and only if the impulse response  $h[n]$  is absolutely summable: (7)

$$\sum_{n=-\infty}^{\infty} |h[n]| < \infty$$

- b) Determine whether the system described by the equation

$$y[n] = x[n] + x[n - 1] \quad (7)$$

is causal and stable.

#### Module III

- 15 a) Determine the Laplace Transform and express the ROC of the signal:

$$x(t) = e^{-t}u(t) + e^{-2t}u(t) \quad (7)$$

- b) Derive the Fourier transform of the signal

$$x(t) = e^{-at}u(t)$$

where  $a > 0$  and  $u(t)$  is the unit step function. (7)

- 16 a) Explain the concept of the region of convergence (ROC) in the Laplace transform and its significance for system stability. (7)

- b) For a bandlimited signal with maximum frequency  $f_m = 5$  kHz, determine the minimum sampling frequency required to avoid aliasing. (7)

#### Module IV

- 17 a) Discuss the linearity and time-shifting properties of the DTFT with appropriate mathematical proofs and examples. (7)

- b) Explain any two properties of the DTFS and illustrate their applications with examples. (7)

- 18 a) Derive the Discrete-Time Fourier Series (DTFS) representation of a periodic discrete-time signal  $x[n]$ . Clearly explain the significance of each term in the DTFS equation. (7)

- b) A discrete-time signal is given by

$$x[n] = e^{j\frac{2\pi n}{3}}$$

which is periodic. Using the Discrete-Time Fourier Series (DTFS), find the frequency spectrum and discuss the result. (7)

#### Module V

- 19 a) For a discrete-time system with transfer function

$$H(z) = \frac{z}{z - 0.9}$$

calculate the magnitude and phase response at  $z = e^{j\omega}$ . Discuss the behavior of the system in terms of its frequency response. (7)

- b) List and explain at least three important properties of the Z-transform and provide examples for each. How do these properties help in simplifying the analysis of discrete-time signals? (7)

- 20 a) Find the inverse Z-transform of the following expression using the partial fraction method:

$$X(z) = \frac{z}{z^2 - 0.5z + 0.25} \quad (7)$$

- b) Explain the relationship between the Discrete-Time Fourier Transform (DTFT) and the Z-transform. What is the significance of the unit circle in the Z-plane when analyzing a signal using DTFT? (7)

# **MAR ATHANASIUS COLLEGE OF ENGINEERING**

Government Aided, Autonomous Institution, Kothamangalam, Kerala,  
India

The logo of Mar Athanasius College of Engineering is a circular emblem with a gear-like outer border. Inside the circle, there is a blue sky with a white cross and green hills at the bottom. The text 'B.Tech' is written in the center, and 'Electronics And Communication Engineering' is written below it.

## **B.Tech Electronics And Communication Engineering**

### **SEMESTER 4**

#### **SYLLABUS**

**SEMESTER 4**

| <b>SLOT</b>  | <b>COURSE NO.</b> | <b>COURSES</b>                                       | <b>L-T-P-S</b> | <b>HOURS</b> | <b>CREDIT</b> |
|--------------|-------------------|------------------------------------------------------|----------------|--------------|---------------|
| A            | B24MA2T04A        | Stochastic Processes and Numerical Methods           | 3-1-0-5        | 4            | 4             |
| B            | B24EC2T04         | Solid State Devices                                  | 3-1-0-5        | 4            | 4             |
| C            | B24EC2T05         | Signals and Systems                                  | 3-1-0-5        | 4            | 4             |
| D            | B24EC2T06         | Linear Integrated Circuits                           | 3-1-0-4        | 4            | 3             |
| E            | B24HU2T02         | Entrepreneurship and Management Skills for Engineers | 2-1-0-4        | 3            | 3             |
| F            | B24EC2T07         | FPGA Based System Design                             | 2-1-0-4        | 3            | 3             |
| G            | B24EC2L05         | Microcontroller Lab                                  | 0-0-3-2        | 3            | 2             |
| H            | B24EC2L06         | HDL Lab                                              | 0-0-3-2        | 3            | 2             |
| M            | B24ECM4X          | Minor                                                | 3-1-0-5        | 4            | 4             |
| N            | B24ECH4X          | Honours                                              | 3-1-0-5        | 4            | 4             |
| <b>TOTAL</b> |                   |                                                      |                | <b>36</b>    | <b>25</b>     |

**MINOR**

| <b>COURSE NO</b> | <b>Courses</b>                            |
|------------------|-------------------------------------------|
| B24ECM41         | Microcontrollers                          |
| B24ECM42         | Digital Communication                     |
| B24ECM43         | Introduction To Digital Signal Processing |

**HONOURS**

| <b>COURSE NO</b> | <b>Courses</b>                         |
|------------------|----------------------------------------|
| B24ECH41         | Nano Electronics                       |
| B24ECH42         | Stochastic Processes For Communication |
| B24ECH43         | Stochastic Signal Processing           |

| B24MA2T04A | STOCHASTIC PROCESSES AND NUMERICAL METHODS | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|------------|--------------------------------------------|---|---|---|---|--------|----------------------|
|            |                                            | 3 | 1 | 0 | 5 | 4      | 2024                 |

**Preamble:**

This course introduces students to the modern theory of probability and statistics, covering important models of random variables and analysis of random processes using appropriate time and frequency domain tools. A brief course in numerical methods familiarises students with some basic numerical techniques for finding roots of equations, evaluating definite integrals solving systems of linear equations and solving ordinary differential equations which are especially useful when analytical solutions are hard to find.

**Prerequisites**

Nil

**Course Outcomes:**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                                                                      |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Apply the concept, properties and important models of discrete random variables and, using them, analyse suitable random phenomena and model variables in engineering systems.<br>(Cognitive Knowledge Level: Apply) |
| <b>CO 2</b> | Apply the concept, properties and important models of continuous random variables and, using them, analyse suitable random phenomena.<br>(Cognitive Knowledge Level: Apply)                                          |
| <b>CO 3</b> | Apply bivariate probability distributions to model complex systems and examine stochastic processes using autocorrelation, power spectrum.<br>(Cognitive Knowledge Level: Apply)                                     |
| <b>CO 4</b> | Apply numerical techniques for root-finding, interpolation, and integration, and evaluate round-off, truncation, and relative computational errors.<br>(Cognitive Knowledge Level: Apply)                            |
| <b>CO 5</b> | Apply standard numerical techniques for solving systems of equations, fitting curves on given numerical data and solving ordinary differential equations.<br>(Cognitive Knowledge Level: Apply)                      |

### Mapping of Course Outcomes with Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 2    | 1    |      | 1    |      |      |      |      |      |       |       |
| CO 2 | 2    | 1    |      | 1    |      | 1    |      |      |      |       |       |
| CO 3 | 2    | 1    |      | 1    |      |      | 1    |      |      |       |       |
| CO 4 | 1    | 2    |      | 1    | 1    |      |      |      |      |       | 1     |
| CO 5 | 1    | 2    |      | 1    | 1    | 1    |      |      |      |       |       |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                     | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|---------------------|---------------------------------------|
|                  | Test 1<br>(% Marks)   | Test 2<br>(% Marks) |                                       |
| Remember         | 30                    | 30                  | 30                                    |
| Understand       | 40                    | 40                  | 40                                    |
| Apply            | 30                    | 30                  | 30                                    |
| Analyse          |                       |                     |                                       |
| Evaluate         |                       |                     |                                       |
| Create           |                       |                     |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Quiz/Course project         | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contains 10 questions carrying 3 marks each. Part B contains 2 questions from each module, out of which one is to be answered. Each question carries 14 marks and can have a maximum of two subdivisions.



## **SYLLABUS**

### **MODULE 1 (8 hours)**

#### **Univariate Discrete Probability Distributions**

Discrete random variables and their probability distributions, expectation, mean, and variance, binomial distribution, poisson distribution, poisson approximation to the binomial distribution.

**(Text 1: Relevant topics from sections 3.1-3.4, 3.6)**

### **MODULE 2 (8 hours)**

#### **Univariate Continuous Probability Distributions**

Continuous random variables and their probability distributions, expectation, mean, and variance, uniform, exponential, and normal distributions and Central limit theorem (without proof).

**(Text 1: Relevant topics from sections 4.1-4.4, 3.6)**

### **MODULE 3 (11 hours)**

#### **Bivariate Probability Distribution and Stochastic Processes**

Discrete bivariate distributions, marginal distributions, independent random variables, expectation (multiple random variables). Continuous bivariate distributions, marginal distributions, independent random variables, expectation (multiple random variables), i.i.d random variables. Random processes and classification, mean and autocorrelation, wide sense stationary (WSS) processes, autocorrelation and power spectral density of WSS processes and their properties.

**(Text 2 : Relevant topics from sections 8.1-8.5, 8.7, Text 1: Relevant topics from section 5.1)**

### **MODULE 4 (9 hours)**

#### **Numerical Methods - I**

Errors in numerical computation-round-off, truncation, and relative error, solution of equations - Newton-Raphson method. Interpolation - finite differences, Newton's forward and backward difference method, Newton's divided difference method and Lagrange's method. Numerical integration - Trapezoidal rule and Simpson's 1/3rd rule. (Proof or derivation of the formulae not required for any of the methods in this module).

**(Text 3: Relevant topics from sections 19.1, 19.2, 19.3, 19.5)**

## **MODULE 5 (9 hours)**

### **Numerical methods - II**

Solution of linear systems - Gauss-Seidel and Jacobi iteration methods. Curve fitting-method of least squares, fitting straight lines and parabolas. Solution of ordinary differential equations - Euler and Classical Runge-Kutta method of second and fourth order. (Proof or derivation of the formulae not required for any of the methods in this module)

**(Text 3: Relevant topics from sections 20.3, 20.5, 21.1)**

#### **Text Books**

1. Jay L. Devore, *Probability and Statistics for Engineering and the Sciences*, Cengage, 8th ed., 2012.
2. Oliver C. Ibe, *Fundamentals of Applied Probability and Random Processes*, Elsevier, 2005.
3. Erwin Kreyszig, *Advanced Engineering Mathematics*, John Wiley & Sons, 10th ed., 2016.

#### **Reference Books**

1. Hossein Pishro-Nik, *Introduction to Probability, Statistics and Random Processes*, Kappa Research, 2014. (Also available online at [www.probabilitycourse.com](http://www.probabilitycourse.com))
2. V. Sundarapandian, *Probability, Statistics and Queueing theory*, PHI Learning, 2009.
3. Gubner, *Probability and Random Processes for Electrical and Computer Engineers*, Cambridge University Press, 2006.
4. B. S. Grewal, *Higher Engineering Mathematics*, Khanna Publishers, 36th ed., 2010.

## COURSE CONTENTS AND LECTURE SCHEDULE

| No       | Topic                                                                                                                  | No of Lecture/Tutorial Hours |
|----------|------------------------------------------------------------------------------------------------------------------------|------------------------------|
| <b>1</b> | <b>Module 1: Univariate Discrete probability Distributions</b>                                                         | <b>8</b>                     |
| 1.1      | Discrete Probability distributions                                                                                     | 4                            |
| 1.2      | Binomial distribution-mean, variance, poisson distribution-mean, variance, poisson approximation to binomial           | 4                            |
| <b>2</b> | <b>Module 2: Univariate Continuous Probability Distributions</b>                                                       | <b>8</b>                     |
| 2.1      | Continuous random variables and probability distributions, expected value, mean and variance                           | 3                            |
| 2.2      | Uniform, exponential and normal distributions, mean and variance of these distributions                                | 4                            |
| 2.3      | Central limit theorem                                                                                                  | 1                            |
| <b>3</b> | <b>Module 3: Stochastic processes</b>                                                                                  | <b>11</b>                    |
| 3.1      | Discrete bivariate distributions, marginal distributions, independence of random variables (discrete), expected values | 2.5                          |
| 3.2      | Continuous bivariate distributions, marginal distributions, independent random variables, expected values              | 2.5                          |
| 3.3      | Random process - definition and classification, mean, autocorrelation                                                  | 2                            |
| 3.4      | WSS processes its autocorrelation function and properties                                                              | 2                            |
| 3.5      | Power spectral density                                                                                                 | 2                            |
| <b>4</b> | <b>Module 4: Numerical methods-I</b>                                                                                   | <b>9</b>                     |
| 4.1      | Roots of equations - Newton-Raphson                                                                                    | 2                            |
| 4.2      | Interpolation - finite differences, Newton's forward and backward formula                                              | 3                            |
| 4.3      | Newton's divided difference method, Lagrange's method                                                                  | 2                            |
| 4.4      | Numerical integration -Trapezoidal rule and Simpson's 1/3rd rule                                                       | 2                            |
| <b>5</b> | <b>Module 5: Numerical methods - II</b>                                                                                | <b>9</b>                     |
| 5.1      | Solution of linear systems - Gauss-Seidel method, Jacobi iteration                                                     | 2                            |
| 5.2      | Curve-fitting - fitting straight lines and parabolas to pairs of data points using method of least squares             | 2                            |
| 5.3      | Solution of ODE-Euler and Classical Runge-Kutta methods of second and fourth order                                     | 5                            |
|          | <b>Total</b>                                                                                                           | <b>45 Hours</b>              |

## CO ASSESSMENT QUESTIONS

### Course Outcome 1 (CO 1)

1. The probability that a batsman scores a century in a cricket match is  $\frac{1}{3}$ . Find the probability that out of 5 matches, he may score century in (i) at least 2 matches (ii) at most 2 matches (iii) no match.
2. A random variable follows Poisson distribution such that  $P(X = 0) = \frac{2}{3}P(X = 1)$  Find
  - (a)  $P(X=1)$
  - (b)  $P(X>1)$
3. Of all customers purchasing automatic garage-door openers, 75% purchase a chain-driven model. Let  $X$  the number among the next 15 purchasers who select the chain-driven model.
  - (a) What is the pmf of  $X$ ?
  - (b) If the store currently has in stock 10 chain-driven models and 8 shaft-driven models, what is the probability that the requests of these 15 customers can all be met from existing stock?

### Course Outcome 2 (CO 2)

1. The heights of adult men in a city are normally distributed with a mean  $\mu = 70$  inches and a standard deviation  $\sigma = 3$  inches. What is the probability that a randomly selected man is taller than 73 inches?
2. Assume that the time between arrivals of customers at a particular bank is exponentially distributed with a mean of 4 minutes
  - (a) Find the probability that the time between arrivals is greater than 5 minutes.
  - (b) Find the probability that the time between arrivals is between 1 and 4 minutes.
3. Derive the mean and variance of uniform distribution

### Course Outcome 3 (CO 3)

1. A random process  $X(t)$  has a power spectral density given by

$$S_{XX}(\omega) = \begin{cases} 4 - \frac{\omega^2}{9}, & |\omega| \leq 6 \\ 0, & \text{otherwise} \end{cases}$$

Determine the average power.

2. A random process  $X(t)$  is given by  $X(t) = Y\cos(2\pi t)$ ,  $t \geq 0$  where  $Y$  is a random variable that is uniformly distributed between 0 and 2. Find the expected value and auto correlation function of  $X(t)$ .
3. A random process  $Y(t)$  is given by  $Y(t) = A\cos(\omega t + \phi)$  where  $A, \omega, \phi$  are independent variables. Assume that  $A$  has mean 3 and a variance of 9,  $\phi$  is uniformly distributed between  $-\pi$  and  $\pi$ , and  $\omega$  is uniformly distributed between  $-6$  and  $6$ . Determine if the process is stationary in the wide sense.

#### Course Outcome 4 (CO 4)

1. Use Newton-Raphson method find correct to 4 decimals places, the root between 0 and 1 of the equation  $x^3 - 6x + 4 = 0$ .
2. A river is 80m wide. The depth  $y$  in meters at a distance  $x$  meters from one bank is given by the following table. Find approximately the area of cross section.

|   |   |    |    |    |    |    |    |    |    |
|---|---|----|----|----|----|----|----|----|----|
| X | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 |
| Y | 0 | 5  | 8  | 10 | 15 | 12 | 7  | 3  | 1  |

3. Using Lagrange's interpolation formula, fit a polynomial to the given data.

|   |   |   |   |   |
|---|---|---|---|---|
| X | 1 | 2 | 7 | 8 |
| Y | 4 | 5 | 5 | 4 |

#### Course Outcome 5 (CO 5)

1. Solve the equations using Gauss elimination method.  
$$\begin{aligned}x + 2y + z &= 3 \\2x + 3y + 2z &= 5 \\3x - 5y + 5z &= 2 \\3x + 9y - z &= 4\end{aligned}$$
2. Obtain the value of  $y$  at  $x = 0.2$  using Runge- Kutta method of fourth order for the differential equation  $\frac{dy}{dx} = 1 + y^2$  with  $h = 0.2$ ,  $y(0) = 0$ .
3. Write the normal equations for fitting the curve  $y = a + bx^2$ .

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2026

Course Code: B24MA2T04A

Course Name: STOCHASTIC PROCESSES AND NUMERICAL METHODS  
Common to EEE and ECE

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Determine the binomial distribution for which mean is 4 and variance is 3.
2. Suppose  $E(X) = 5$  and  $E[X(X - 1)] = 25$ . Find  $E(X^2)$ .
3. Derive the mean and variance of exponential distribution.
4. Find mean and variance of the Uniform distribution  $f(x) = \frac{1}{10}$ ,  $10 \leq x \leq 20$ .
5. Define stationary random process. Define two types of stationary random process.
6. Write down the properties of the power spectral density.
7. Use trapezoidal rule to evaluate  $\int_0^1 x^3$  considering five subintervals.
8. Write the formula for finding  $\sqrt{5}$  using Newton-Raphson's Method.
9. Using Euler's method, find  $y(0.2)$  if  $y' = x + y$ ,  $y(0) = 1$ .
10. Write the normal equations for fitting the curve  $y = a + bx^2$ .



**PART B**

**Answer any one question from each module. Each question carries 14 marks.**

11. (a) A car hire firm has 2 cars which it hires out day by day. The number of demands for a car on each day is distributed as a Poisson distribution with mean 2. Calculate the proportion of days on which (i) neither car is used (ii) some demand is refused. (7 marks)
- (b) Suppose that 20% of all copies of a particular textbook fail a certain binding strength test. Let  $X$  denote the number among 15 randomly chosen copies that fail the test. Using the table of Binomial distributions or by direct calculation. 1) Find the probability that at most 8 will fail the test. 2) Find the probability that exactly 8 will fail the test. 3) Find the probability that at least 8 will fail the test. 4) Find the probability that failure is between 4 and 7 (inclusive). (7 marks)

**OR**

12. (a) The number of gamma rays emitted per second by a certain radioactive substance follows a Poisson distribution with mean 8. Determine the probability that (i) three particles are emitted in one second (ii) at most one particle is emitted in one second (iii) more than one particle is emitted in one second. (7 marks)
- (b) Derive the mean and variance of binomial distribution. (7 marks)
13. (a) The weight of certain brand of shampoo packets are uniformly distributed between 9.3 gm and 10.5 gm. In a random lot of 100 packets how many packets (i) exceed 10 gm (ii) are below 10.2 gm. (7 marks)
- (b) In a normal distribution 7% of the items are under 35 and 10% of the items are above 55. Calculate the mean and variance. (7 marks)

**OR**

14. (a) The time (in hours) required to repair a machine is exponentially distributed with mean 2. (i) What is the probability that the repairing time exceeds 2 hours? (ii) What is the conditional probability that a repair takes at least 10 hours given that its duration exceeds 9 hours? (7 marks)
- (b) The life time of a certain type of electric bulbs may be considered to follow exponential distribution with mean 50hrs. Use central limit theorem to find the approximate probability that 100 of these electric bulbs will provide a total of more than 6000hrs of burning time. (7 marks)
15. (a) Verify whether  $X$  and  $Y$  are independent if  $f(x, y) = 24xy$ ,  $0 \leq X \leq 1$ ,  $0 \leq Y \leq 1$ ,  $X + Y \leq 1$ . (7 marks)
- (b) Find the power spectral density function of the WSS process whose autocorrelation function is  $e^{-\alpha\tau^2}$ . (7 marks)

**OR**

16. (a) The power spectral density of a WSS process is  $\frac{\omega^2 + 9}{\omega^4 + 5\omega^2 + 4}$ . Find the auto-correlation function and power of the process.

(7 marks)

- (b) The joint probability distribution of  $X$  and  $Y$  is given by  $f(x, y) = \frac{2x + 3y}{54}$ ,  $X = 1, 2$ ;  $Y = 1, 2, 3$ . Find the marginal distributions of  $X$  and  $Y$ .

(7 marks)

17. (a) Use Lagrange's interpolation formula to find  $y(2)$  from the following table

|   |   |    |    |
|---|---|----|----|
| X | 1 | 3  | 4  |
| Y | 1 | 27 | 64 |

(7 marks)

- (b) Compute  $y(13)$  using Newton's Backward difference formula, if given

|   |    |    |    |    |    |
|---|----|----|----|----|----|
| X | 3  | 6  | 9  | 12 | 15 |
| Y | 18 | 27 | 36 | 45 | 54 |

(7 marks)

OR

18. (a) Evaluate  $\int_0^2 x e^x dx$  using Simpson's  $\frac{1}{3}$ rd rule with  $n = 8$ .

(7 marks)

- (b) The positive root of the equation  $x^3 + x + 1 = 0$  using Newton-Raphson method correct to 4 decimal places.

(7 marks)

19. (a) Solve by Gauss-Seidel method the following system:

$$28x + 4y - z = 32$$

$$x + 3y + 10z = 24$$

$$2x + 17y + 4z = 35$$

(7 marks)

- (b) Fit a straight line to the points (0,2), (2,0), (3, -2), (5, -3) using method of least squares.

(7 marks)

OR

20. (a) Apply Gauss-Seidel method to solve the equations

$$20x + y - 2z = 17$$

$$3x + 20y - z = -18$$

$$2x - 3y + 20z = 25$$

(7 marks)

- (b) Solve using Runge-Kutta method of order 4:  $y' = 8.5 - 20x + 12x^2 - 2x^3$ ,  $y(0) = 1$  for  $x = 0.5$  [Choose  $h = 0.5$ ].

(7 marks)

| B24EC2T04 | SOLID STATE DEVICES | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|---------------------|---|---|---|---|--------|----------------------|
|           |                     | 3 | 1 | 0 | 5 |        |                      |

### Preamble

This course equip the students to understand the physics and working of solid state devices.

### Prerequisites

B24PH1T01A: Engineering Physics

B24ES1T02 : Basics Of Electrical & Electronics Engineering.

### Course Outcomes

After the completion of the course the student will be able to:

|             |                                                                                                                                                                                                                                       |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Students will be able to recall the concepts of intrinsic and extrinsic semiconductors, Fermi level, and doping effects on energy band diagrams. [Remember]                                                                           |
| <b>CO 2</b> | Students will be able to explain the mechanisms of carrier drift, diffusion, and the relationship between mobility, conductivity, and temperature in semiconductors. [Understand]                                                     |
| <b>CO 3</b> | Students will be able to explain PN junction basics (contact potential, biasing, ideal diode equation), metal-semiconductor contacts (current-voltage traits), and BJT operation (amplification, base width modulation). [Understand] |
| <b>CO 4</b> | Explain the concept of MOSFETs and derive the expression for drain current in MOSFETs.[Understand,Apply]                                                                                                                              |
| <b>CO 5</b> | Analyse different short channel effects due to scaling of MOSFET, special diodes.[Analyze]                                                                                                                                            |

### Mapping of Course Outcomes With Program Outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 2    | 3    | 3    | 1    |      |      |      |      |      |       | 2     |
| <b>CO 2</b> | 1    | 3    | 3    | 1    |      |      |      |      |      |       | 2     |
| <b>CO 3</b> | 3    | 2    | 2    |      | 1    |      |      |      |      |       | 2     |
| <b>CO 4</b> | 3    | 2    | 2    | 1    | 1    |      |      |      |      |       | 2     |
| <b>CO 5</b> | 2    | 3    | 3    | 3    | 1    |      |      |      |      |       | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 30                    | 30                 | 30                                    |
| Understand       | 40                    | 40                 | 40                                    |
| Apply            | 30                    | 30                 | 30                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE I

**Introduction to semiconductors:** Elemental and compound semiconductors, Intrinsic and Extrinsic semiconductors, concept of effective mass, Fermi Dirac distribution, Fermi level, Doping & Energy band diagram, Equilibrium and steady state conditions, Density of states & Effective density of states, Equilibrium concentration of electrons and holes.

**Excess carriers in semiconductors :** Generation and recombination mechanisms of excess carriers (derivation not needed), quasi Fermi levels.

### MODULE 2

**Carrier transport in semiconductors :** Drift, conductivity and mobility, variation of mobility with temperature and doping.

**Charge Carrier Dynamics :** Diffusion, Einstein relations, Poisson equations, Continuity equations, Current flow equations, Concept of Diffusion length. Gradient of quasi Fermi level.

### MODULE 3

**PN junctions :** Contact potential, Electrical Field, Potential and Charge distribution at the junction, Biasing and Energy band diagrams, Ideal diode equation and its application. Metal Semiconductor contacts, Electron affinity and work function, Ohmic and Rectifying Contacts, current voltage characteristics.

**Bipolar Junction Transistor :** Transistor action and amplification parameters, Base width modulation.

### MODULE 4

**MOS Devices:** Ideal MOS capacitor, band diagrams at equilibrium, accumulation, depletion and inversion, CV characteristics, threshold voltage, body effect.

**MOSFET:** Structure, types, Drain current equation (derive)- linear and saturation region, Drain characteristics, transfer characteristics.

### MODULE 5

**MOSFET scaling :** Need for scaling, constant voltage scaling and constant field scaling. Sub threshold conduction in MOS.

**Short channel effects :** Channel length modulation, Drain Induced Barrier Lowering, Velocity Saturation, Threshold Voltage Variations and Hot Carrier Effects.

**Specialized Transistor Structures:** Operation of HEMT, FinFET and IGBT.

**Special Diodes :** Tunnel diode, Photo diode ,LED.

**Text Books**

1. Ben G Streetman and Sanjay Kumar Banarjee, Solid State Devices, Pearson 6/e, 2010.
2. Sung Mo Kang, CMOS Digital integrated circuits : Analysis and Design, Tata Mc GrawHill Third Edition 2002.

**Reference Books**

1. Neamen, Semiconductor Physics and Devices, McGraw Hill, 4/e, 2012
2. Sze S.M., Semiconductor Devices: Physics and Technology, John Wiley, 3/e, 2005
3. Pierret, Semiconductor Devices Fundamentals, Pearson, 2006
4. Sze S.M., Physics of Semiconductor Devices, John Wiley, 3/e, 2005
5. Achuthan, K N Bhat, Fundamentals of Semiconductor Devices, 1e, McGraw Hill, 2015.
6. Yannis Tsividis, Operation and Modelling of the MOS Transistor, Oxford University Press.
7. Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic, Digital Integrated Circuits - A Design Perspective, PHI.



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                    | No of Lecture/Tutorial Hours |
|-----|------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                          | <b>10</b>                    |
| 1.1 | Elemental and compound semiconductors, Intrinsic and Extrinsic semiconductors, Effective mass.                                           | 2                            |
| 1.2 | Fermi Dirac distribution, Fermi level, Doping and Energy band diagram,                                                                   | 2                            |
| 1.3 | Equilibrium and steady state conditions, Density of states and Effective density of states                                               | 1                            |
| 1.4 | Equilibrium concentration of electrons and holes.                                                                                        | 1                            |
| 1.5 | Excess carriers in semiconductors: Generation and recombination mechanisms of excess carriers, quasi Fermi levels.                       | 2                            |
| 1.6 | TUTORIAL.                                                                                                                                | 2                            |
|     | <b>Module 2</b>                                                                                                                          | <b>8</b>                     |
| 2.1 | Carrier transport in semiconductors, drift, conductivity and mobility, variation of mobility with temperature and doping.                | 2                            |
| 2.2 | Diffusion equation                                                                                                                       | 1                            |
| 2.3 | Einstein relations, Poisson equations                                                                                                    | 1                            |
| 2.4 | Poisson equations, Continuity equations, Current flow equations                                                                          | 1                            |
| 2.5 | Concept of diffusion length, Gradient of quasi Fermi level                                                                               | 1                            |
| 2.6 | TUTORIAL                                                                                                                                 | 2                            |
|     | <b>Module 3</b>                                                                                                                          | <b>11</b>                    |
| 3.1 | PN junctions : Contact potential, Electrical Field, Potential and Charge distribution at the junction, Biasing and Energy band diagrams, | 2                            |
| 3.2 | Metal Semiconductor contacts, Electron affinity and work function, Ohmic and Rectifying Contacts, current voltage characteristics.       | 2                            |
| 3.3 | Ideal diode equation and its application.                                                                                                | 2                            |
| 3.4 | Bipolar junction transistor – working,, current components, Transistor action, Base width modulation.                                    | 2                            |
| 3.5 | Derivation of terminal currents in BJT                                                                                                   | 2                            |
| 3.6 | TUTORIAL                                                                                                                                 | 1                            |
|     | <b>Module 4</b>                                                                                                                          | <b>8</b>                     |
| 4.1 | Ideal MOS capacitor, band diagrams at equilibrium, accumulation, depletion and inversion, C-V characteristics                            | 2                            |
| 4.2 | Threshold voltage, body effect                                                                                                           | 1                            |
| 4.3 | MOSFET-structure, working, types,                                                                                                        | 2                            |
| 4.4 | Drain current equation (derive)- linear and saturation region, Drain characteristics, transfer characteristics                           | 2                            |
| 4.5 | TUTORIAL                                                                                                                                 | 1                            |

|     |                                                                                                                                                              |                 |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
|     | <b>Module 5</b>                                                                                                                                              | <b>11</b>       |
| 5.1 | MOSFET scaling – need for scaling, constant voltage scaling and constant field scaling.                                                                      | 2               |
| 5.2 | Sub threshold conduction in MOS.                                                                                                                             | 1               |
| 5.3 | Short channel effects- Channel length modulation, Drain Induced Barrier Lowering, Velocity Saturation, Threshold Voltage Variations and Hot Carrier Effects. | 3               |
| 5.4 | Non-Planar MOSFETs: Fin FET –Structure, operation and advantages                                                                                             | 1               |
| 5.5 | Operation of HEMT,Fin FET and IGBT.                                                                                                                          | 2               |
| 5.6 | Special Diodes : Tunnel diode, Photo diode ,LED.                                                                                                             | 2               |
|     | <b>Total Hours</b>                                                                                                                                           | <b>48 Hours</b> |

### CO ASSESSMENT QUESTIONS

**Course Outcome 1 (CO1): Solve for the carrier concentration inside semiconductors using the concepts of band diagram and Fermi Dirac distribution function.**

1. Derive the expression for equilibrium electron and hole concentration.
2. Explain the different recombination mechanisms circuit.
3. Solve numerical problems related to carrier concentrations at equilibrium, energy band diagrams and excess carrier concentrations in semiconductors.

**Course Outcome 2 (CO2) : Apply current flow equations to calculate drift and diffusion currents inside semiconductors.**

1. Derive the expression for diffusion current and drift current in semiconductors.
2. Show that diffusion length is the average distance a carrier can diffuse before recombining.

**Course Outcome 3 (CO3): Explain the energy band diagrams and charge distributions in pn junction diodes, metal semiconductor junctions and bipolar junction transistors.**

1. Derive ideal diode equation.
2. Derive the expression for minority carrier distribution and terminal currents in a BJT.

3. Solve numerical problems related to PN junction diode and BJT

**Course Outcome 4 (CO4): Explain the concept of MOSFETs and derive the expression for drain current in MOSFETs.**

1. Illustrate the working of a MOS capacitor in the three different regions of operation.
2. Explain the working of MOSFET and derive the expression for drain current.
3. Solve numerical problems related to currents and parameters associated with MOSFETs.

**Course Outcome 5 (CO5): Analyse different short channel effects due to scaling of MOSFET, special diodes.**

1. Explain the different MOSFET scaling techniques.
2. Explain the short channel effects associated with reduction in size of MOSFET.
3. Discuss some special diodes.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FOURTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2024**

**Course Code: B24EC2T04**

**Course Name: SOLID STATE DEVICES**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define Fermi Dirac distribution function of semiconductor.
2. Draw the energy band diagram under equilibrium for i) Intrinsic ii) n-type iii) p-type semiconductors.
3. Distinguish between lattice scattering and ionized impurity scattering.
4. Show that diffusion length is the average length a carrier moves before recombination.
5. Derive the expression for contact potential in a PN junction diode.
6. Explain Early effect? Mention its effect on terminal currents of a BJT.
7. Derive the expression for threshold voltage of a MOSFET.
8. Explain the transfer characteristics of a MOSFET in linear and saturation regions.
9. Explain Subthreshold conduction in a MOSFET. Write the expression for Subthreshold current.
10. How does channel length modulation affect the drain characteristics of a MOSFET ?

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Derive law of mass action (8)  
b) An n-type Si sample with  $N_d = 10^5 \text{ cm}^{-3}$  is steadily illuminated such that  $g_{op} = 10^{21} \text{ EHP/cm}^3 \text{ s}$ . If  $\tau_n = \tau_p = 1 \mu\text{s}$  for this excitation, calculate the separation in the Quasi-Fermi levels ( $F_n - F_p$ ). Draw the Energy band diagram. (6)
12. a) Explain the different types of indirect recombination mechanism in a semiconductor. How do they differ from direct recombination. (8)  
b) The Fermi level in a Silicon sample at 300 K is located at 0.4 eV below the bottom of the conduction band. The effective densities of states  $N_C = 2.82 \times 10^{19} \text{ cm}^{-3}$  and  $N_V = 1.53 \times 10^{19} \text{ cm}^{-3}$ . Determine (a) the electron and hole concentrations at 300K (b) the intrinsic carrier concentration at 400 K. (6)

**Module II**

13. a) Derive the expression for mobility, conductivity and Drift current density in a semiconductor. (8)  
b) A Si bar 0.1  $\mu\text{m}$  long and  $100 \text{ m}^2$  in cross-sectional area is doped with  $10^{17} \text{ cm}^{-3}$  phosphorus. Find the current at 300 K with 10 V applied. (b). How long will it take an average electron to drift 1  $\mu\text{m}$  in pure Si at an electric field of 100 V/cm? (6)
14. a) A GaAs sample is doped so that the electron and hole drift current densities are equal in an applied electric field. Calculate the equilibrium concentration of electron and hole, the net doping and the sample resistivity at 300 K.  
Given  $\mu_n = 8500 \text{ cm}^2/\text{Vs}$ ,  $\mu_p = 400 \text{ cm}^2/\text{Vs}$ ,  $n_i = 1.79 \times 10^6 \text{ cm}^{-3}$ . (7)  
b) Define Hall effect ? Derive the expression for carrier concentration and mobility in terms of Hall voltage. (7)

**Module III**

15. a) With suitable assumptions derive the expression of the ideal diode equation. Plot the minority carrier distribution across the pn junction in forward bias condition. (9)  
b) Boron is implanted into an n-type Si sample ( $N_d = 10^{16} \text{ cm}^{-3}$ ), forming an abrupt junction of square cross section with area  $= 2 \times 10^{-3} \text{ cm}^2$ . Assume that the acceptor concentration in the p-type region is  $N_a = 4 \times 10^{18} \text{ cm}^{-3}$ . Calculate  $V_0$ ,  $W$ ,  $Q^+$  and  $E_0$  for this junction at equilibrium (300 K). (5)
16. With the aid of energy band diagrams, explain how a metal – N type Schottky contact function as rectifying and ohmic contacts. . (14)

**Module IV**

17. a) Starting from the fundamentals, derive the expression for drain current of a MOSFET in the two regions of operation. (8)

- b) Find the maximum depletion width, minimum capacitance  $C_i$ , and threshold voltage for an ideal MOS capacitor with a 10-nm gate oxide ( $\text{SiO}_2$ ) on p-type Si with  $N_a = 10^{16} \text{ cm}^{-3}$ . (b) Include the effects of flat band voltage, assuming an n + polysilicon gate and fixed oxide charge of  $5 \times 10^{10} \text{ q (C/cm}^2\text{)}$ . (6)
18. a) Explain the CV characteristics of an ideal MOS capacitor. (8)
- b) For a long channel n-MOSFET with  $W = 1 \text{ V}$ , calculate the  $V_G$  required for an  $I_{D(\text{sat.})}$  of 0.1 mA and  $V_{D(\text{sat.})}$  of 5V. Calculate the small-signal output conductance  $g$  and  $V$  the transconductance  $g_{m(\text{sat.})}$  at  $V_D = 10 \text{ V}$ . Recalculate the new ID for  $(V_G - V_T) = 3$  and  $V_D = 4 \text{ V}$ . (6)

**Module V**

19. Explain the concept of constant field scaling. What are the advantages compared to constant voltage scaling (14)
20. With the aid of suitable diagrams explain the structure and working of a FINFET. List its advantages (14)



| B24EC2T05 | SIGNALS AND SYSTEMS | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|---------------------|---|---|---|---|--------|----------------------|
|           |                     | 3 | 1 | 0 | 5 |        |                      |

### Preamble

This course introduces signals and systems in continuous and discrete-time domains, emphasizing signal analysis and classification. Students will learn frequency-domain techniques using Fourier series, Fourier transforms, and Z-transforms, along with LTI system design and stability analysis. It prepares students for advanced topics in digital signal processing, communication, and control systems.

### Prerequisites

Nil

### Course Outcomes

After the completion of the course the student will be able to:

|             |                                                                                                                                                                  |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Classify and differentiate continuous and discrete-time signals and systems based on their properties and perform basic signal operations [Remember, Understand] |
| <b>CO 2</b> | Analyze signals in the frequency domain using various transforms and evaluate their properties [Apply, Analyze]                                                  |
| <b>CO 3</b> | Evaluate the stability and causality of linear time-invariant (LTI) systems using convolution operations [Apply, Analyze]                                        |
| <b>CO 4</b> | Apply sampling theorem to discretize continuous time signals [Apply, Analyze]                                                                                    |
| <b>CO 5</b> | Interpret the use of various transforms to analyze continuous and discrete time LTI systems [Understand, Apply, Analyze]                                         |

### Mapping of Course Outcomes With Program Outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 2    | 1    | 2    | 1    |      |      |      |      |       | 2     |
| <b>CO 2</b> | 3    | 3    | 2    | 3    | 1    |      |      |      |      |       | 2     |
| <b>CO 3</b> | 3    | 3    | 2    | 3    | 1    |      |      |      |      |       | 2     |
| <b>CO 4</b> | 3    | 2    | 2    | 2    | 1    |      |      |      |      |       | 2     |
| <b>CO 5</b> | 3    | 3    | 3    | 3    | 2    |      |      |      |      |       | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 20                    | 20                 | 20                                    |
| Apply            | 40                    | 40                 | 40                                    |
| Analyse          | 20                    | 20                 | 20                                    |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Classification of Signals and Systems:** Elementary signals, Continuous time and Discrete time signals and systems: Step - Ramp - Pulse - Impulse - Real and Complex Exponentials - Sinusoids. Signal Transformations: Time Shifting - Time Scaling - Time Reversal - Amplitude Scaling. Classification of Signals: Continuous Time (CT) and Discrete Time (DT) Signals - Periodic & Aperiodic Signals - Deterministic & Random Signals - Energy & Power Signals-Even and Odd Signals. Classification of Systems: Continuous-Time (CT) systems and discrete-time (DT) systems - Linear & Nonlinear Systems - Time-Variant & Time-Invariant Systems - Causal & Non-Causal Systems - Stable & Unstable Systems.

### MODULE 2

**Frequency domain representation of continuous time signals :** Continuous time Fourier series - Exponential Fourier series-representation of periodic signals. Continuous-time Fourier transform and its properties. Convergence and Gibbs phenomenon, Continuous-time Fourier transform of standard signals. Review of Laplace Transform, ROC of Transfer function, Properties of ROC, Stability and causality conditions. Relation between Fourier and Laplace transforms.

### MODULE 3

**Linear Time-Invariant Continuous Time Systems :** Impulse Response - Convolution Integrals - Differential Equations. Analysis of LTI systems using Laplace and Fourier transforms. Concept of transfer function, frequency response, magnitude, and phase response.

### MODULE 4

**Frequency domain representation of discrete time signals:** Baseband Signal Sampling - Sampling of continuous time signals, Sampling theorem for low pass signals, aliasing Discrete time Fourier series for discrete periodic signals. Discrete time Fourier transform (DTFT) and its properties. Z-Transforms: ROC, properties of Z-Transforms (Proof not needed) Inverse Z-Transforms.

### MODULE 5

**Linear Time-Invariant Discrete Time Systems :** Impulse Response - Difference Equations - Convolution Sum. Relation between DTFT and Z transform, Analysis of discrete time LTI systems using Fourier and Z transforms, Transfer function. Stability and causality

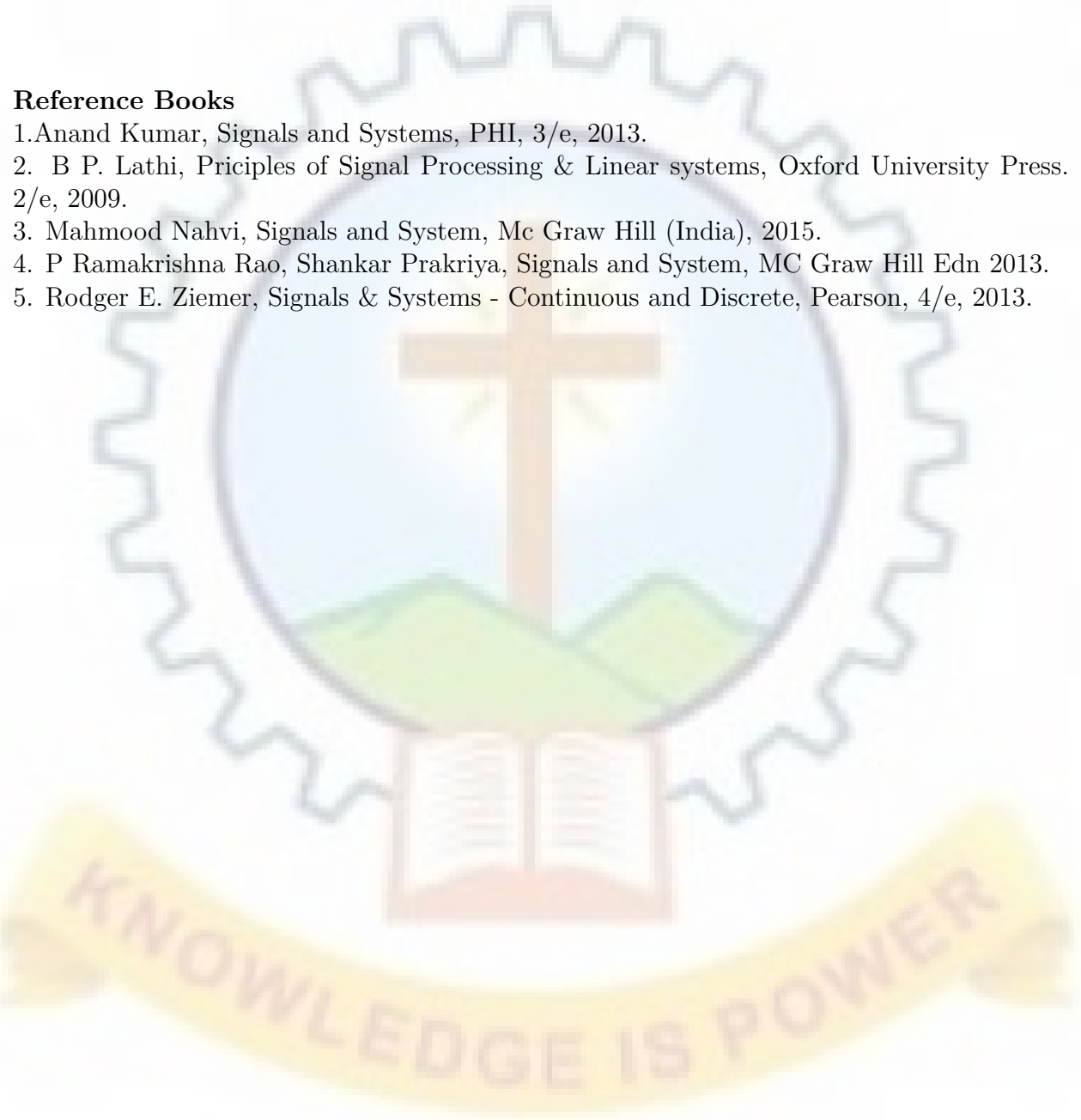
using the Z transform

**Text Books**

1. Alan V. Oppenheim and Alan Willsky, Signals and Systems, PHI, 2/e, 2015.
2. Simon Haykin, Signals & Systems, John Wiley, 2/e, 2021.

**Reference Books**

1. Anand Kumar, Signals and Systems, PHI, 3/e, 2013.
2. B P. Lathi, Principles of Signal Processing & Linear systems, Oxford University Press. 2/e, 2009.
3. Mahmood Nahvi, Signals and System, Mc Graw Hill (India), 2015.
4. P Ramakrishna Rao, Shankar Prakriya, Signals and System, MC Graw Hill Edn 2013.
5. Rodger E. Ziemer, Signals & Systems - Continuous and Discrete, Pearson, 4/e, 2013.



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                                                                                 | No of Lecture/Tutorial Hours |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                                                                                       | <b>10</b>                    |
| 1.1 | Elementary signals, Continuous time and Discrete time signals and systems: Step - Ramp - Pulse - Impulse - Real and Complex Exponentials - Sinusoids                                                                  | 2                            |
| 1.2 | Signal Transformations: Time Shifting - Time Scaling - Time Reversal - Amplitude Scaling.                                                                                                                             | 2                            |
| 1.3 | Classification of Signals: Continuous Time (CT) and Discrete Time (DT) Signals - Periodic & Aperiodic Signals - Deterministic & Random Signals - Energy & Power Signals-Even and Odd Signals                          | 3                            |
| 1.4 | Classification of Systems: Continuous Time (CT) Systems and Discrete Time (DT) Systems - Linear & Nonlinear Systems - Time-Variant & Time-Invariant Systems - Causal & Non-Causal Systems - Stable & Unstable Systems | 3                            |
|     | <b>Module 2</b>                                                                                                                                                                                                       | <b>9</b>                     |
| 2.1 | Frequency domain representation of continuous time signals- Continuous time Fourier series - Exponential Fourier series-representation of periodic signals.                                                           | 2                            |
| 2.2 | Continuous time Fourier transform and its properties. Convergence and Gibbs phenomenon,                                                                                                                               | 2                            |
| 2.3 | Continuous time Fourier transform of standard signals                                                                                                                                                                 | 2                            |
| 2.4 | Review of Laplace Transform, ROC of Transfer function, Properties of ROC, Stability and causality conditions. Relation between Fourier and Laplace transforms.                                                        | 3                            |
|     | <b>Module 3</b>                                                                                                                                                                                                       | <b>8</b>                     |
| 3.1 | Linear Time-Invariant Continuous Time Systems-Impulse Response - Convolution Integrals - Differential Equations                                                                                                       | 3                            |
| 3.2 | Analysis of LTI systems using Laplace and Fourier transforms                                                                                                                                                          | 2                            |
| 3.3 | Concept of transfer function, Frequency response, Magnitude and phase response.                                                                                                                                       | 3                            |
|     | <b>Module 4</b>                                                                                                                                                                                                       | <b>10</b>                    |
| 4.1 | Baseband Signal Sampling - Sampling of continuous time signals, Sampling theorem for low pass signals, aliasing                                                                                                       | 2                            |
| 4.2 | Discrete time Fourier series for discrete periodic signals                                                                                                                                                            | 2                            |
| 4.3 | Discrete time Fourier transform (DTFT) and its properties                                                                                                                                                             | 2                            |
| 4.4 | Z-Transforms: ROC, properties of Z-Transforms (Proof not needed) Inverse Z-Transforms,                                                                                                                                | 4                            |
|     | <b>Module 5</b>                                                                                                                                                                                                       | <b>8</b>                     |
| 5.1 | Linear Time-Invariant Discrete Time Systems-Impulse Response - Difference Equations - Convolution Sum                                                                                                                 | 2                            |

|     |                                                                      |                 |
|-----|----------------------------------------------------------------------|-----------------|
| 5.2 | Relation between DTFT and Z-Transform                                | 1               |
| 5.3 | Analysis of discrete time LTI systems using Fourier and Z transforms | 3               |
| 5.4 | Transfer function. Stability and causality using Z transform         | 2               |
|     | <b>Total Hours</b>                                                   | <b>45 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Demonstrate the relationship between Unit step, Unit ramp and Unit Impulse functions
2. Sketch the signal and test whether it is causal  $x(n) = u(n+5) - u(n-3) + u(n-2)$

#### Course Outcome 2 (CO 2):

1. Show that a square wave has only odd harmonics.
2. Find the Laplace Transform of  $x(t) = e^{-2t} [u(t) - u(t-2)]$

#### Course Outcome 3 (CO 3):

1. Define convolution of  $x(t)$  and  $h(t)$ .
2. Evaluate the discrete-time convolution sum with required plots for the following signal  $y[n] = 3^n u[-n+3] \cdot u[n-2]$

#### Course Outcome 4 (CO 4):

1. What should be the minimum sampling frequency for the correct sampling of the signal  $x(t) = 4\sin(2\pi t) + \cos(5\pi t + 0.1) + \cos(\pi t)$
2. Explain with the help of figures, the effect of sampling in the frequency domain

#### Course Outcome 5 (CO 5):

1. Give the frequency response of a first-order low pass filter. What is the 3-dB cut off frequency?
2. Obtain the transfer function and impulse response for a stable and causal system with difference equation

$$y[n] + \frac{1}{6}y[n-1] - \frac{1}{6}y[n-2] = 3x[n] - \frac{1}{6}x[n-1]$$



MODEL QUESTION PAPER

QP CODE:

Pages: 5

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

FOURTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: B24EC2T05

Course Name: SIGNALS AND SYSTEMS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks

1. Check whether the given signal  $x(t) = (1 + e^{-2t})u(t)$  is an energy signal or power signal.
2. Check for shift invariance & linearity the systems represented by  $y(t) = x^2(t - 1)$
3. State the Dirichlet's conditions for the convergence of Fourier series
4. Find Laplace Transform and sketch ROC for the signal  $x(t) = e^{2t}u(t) + e^{-3t}u(t)$
5. A continuous-time signal  $x(t) = e^{-5t}u(t)$  is applied to a continuous-time system as the input, and the impulse response of the system is  $h(t) = u(t - 3)$ . Obtain the output of the system.
6. Explain what is the transfer function of a system and define the poles and zeros of the transfer function
7. A continuous-time signal  $x(t) = \cos(40t) - \cos(60t)$  is sampled with a time period  $T$ . Can  $x(t)$  be recovered from the samples  $x(nT)$  for  $T = \frac{\pi}{30}$ ? State the reason for the same..
8. Define the Discrete-Time Fourier Transform (DTFT) of a signal  $x[n]$ . Prove that the DTFT is periodic with period  $2\pi$ .
9. What is the output sequence of an LTI system with impulse response  $h(n) = [2, 2]$  to the input  $x(n) = [1, 2, 3, 1]$ ?

10. Determine the impulse response of the system described by the difference equation  $y(n) = ay(n-1) + x(n)$ .

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Test whether the following signals are periodic or not. If periodic, determine the fundamental period and frequency.

i.  $x(t) = 3 \cos(5t + \frac{\pi}{6})$

ii.  $x(t) = e^{(j\pi-2)t}$

(6)

- b) Determine whether the following system is static, time invariant, linear, and causal.  $x(t)$  and  $y(t)$  denote the input and output, respectively. Give an explanation for each.

$$y(t) = t^2x(t) + x(t-2)$$

(8)

12. a) Check whether the following signals are energy or power signals.

i.  $x(t) = e^{-a|t|}, \quad a > 0$

ii.  $x(t) = tu(t)$

(6)

- b) Define an LTI system. Check whether the following system is an LTI system or not.

$$y(t) = 3x(t) + 5$$

(8)

**Module II**

13. a) Using the standard transforms and properties find Fourier Transforms of the following signals.

i.  $x(t) = te^{-2t}u(t)$

ii.  $x(t) = \sin(2\pi t)e^{-t}u(t)$

(6)

- b) Determine the Laplace Transform and express the ROC of the signal:

$$x(t) = e^{-t}u(t) + e^{-2t}u(t)$$

(8)

**Module III**

14. a) Compute the Fourier series of a half wave rectified sinusoid with period  $T$  and amplitude  $A$  (6)

- b) i. Using the frequency shifting property, find the Fourier Transform of

$$x(t) = e^{j2t}u(t)$$

- ii. Using the Time Reversal property, find the Fourier Transform of

$$x(t) = u(-t)$$

(8)

15. a) Evaluate the continuous time convolution integral for the following with proper plots.

$$y(t) = (u(t) - u(t - 2)) * u(t)$$

(7)

- b) i) A certain continuous LTI system is described by the following differential equation.

$$\frac{dy(t)}{dt} + 5y(t) = x(t)$$

- ii) Determine  $y(t)$  using the Fourier Transform for the following inputs:

i.  $x(t) = e^{-2t}u(t)$

ii.  $x(t) = \delta(t)$

(7)

#### Module IV

16. a) Find the response of an LTI system whose input  $x(t)$  and impulse response  $h(t)$  are given:  $x(t) = u(t)$ ,  $h(t) = e^{-at}u(t)$  (8)

- b) Analyze and characterize the LTI system  $x(t)$  using Laplace Transform:

$$x(t) = \frac{2}{3}e^{-t}u(t) + \frac{1}{3}e^{2t}u(t)$$

(6)

17. a) Find the DTFT of the discrete-time signal  $x(n) = a^{|n|}$ ,  $-1 < a < 1$ . (6)

- b) Consider the signal  $x(t) = \cos(2000\pi t) + 10 \sin(10000\pi t) + 20 \cos(5000\pi t)$ .

Determine:

- i. Nyquist rate for this signal

- ii. If the sampling rate is 5000 samples per second, then what is the discrete-time signal  $x(nT_s)$  obtained after sampling, where  $T_s$  is the sampling period and  $n$  is an integer.

(8)

18. (a) Fourier series coefficients of a discrete-time periodic signal  $x[n]$  are given by  $C_k = \cos\left(\frac{k\pi}{4}n + \sin\left(\frac{3k\pi}{4}\right)\right)$ . The period of  $x[n]$  is  $N = 8$ . Determine the sequence  $x[n]$ . (8)

- (b) Determine the  $z$ -transform of the function  $x(n) = (n + 0.5) \left(\frac{1}{3}\right)^n u(n)$ . (6)

**Module V**

19. a) Perform linear convolution of signals  $x_1[n] = [2, 2, 2, 2]$  and  $x_2[n] = [1, 1, 1, 1]$ . (6)  
b) Write the impulse response of the system function whose algebraic expression is given below. Also check and justify the causality and stability.

$$H(z) = \frac{1}{1 - \frac{1}{2}z^{-1}} + \frac{1}{1 - 2z^{-1}}, \quad \frac{1}{2} < |z| < 2$$

(8)

20. a) Determine the transfer function of the system given by the difference equation:

$$y(n) + \frac{1}{4}y(n-1) = x(n) - x(n-1)$$

Calculate the frequency response from its transfer function. Also, obtain the magnitude and phase responses of the given system.

(7)

- b) A certain LTI system is described by the following system function  $H(z) = \frac{z + \frac{1}{2}}{(z-1)(z-\frac{1}{2})}$ . Find the system response to the input  $x(n) = 4^{-(n+2)}u(n)$ . (7)

| <b>B24EC2T06</b> | <b>LINEAR<br/>INTEGRATED<br/>CIRCUITS</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF<br/>INTRODUCTION</b> |
|------------------|-------------------------------------------|----------|----------|----------|----------|---------------|---------------------------------|
|                  |                                           | 3        | 1        | 0        | 4        |               |                                 |

**Preamble**

Analog integrated circuits (ICs) are fundamental components that play a pivotal role in the design of modern electronic systems. Unlike digital ICs, which operate with binary signals, analog ICs process continuous signals that can take on any value within a specified range. These circuits are the backbone of many applications, from amplifying signals in audio systems to controlling power in industrial equipment. The versatility of analog ICs allows them to perform a wide range of functions, such as amplification, filtering, oscillation, and signal modulation, making them indispensable in communication, instrumentation, automotive, and consumer electronics.

**Prerequisites**

B24ECIT04: Analog Circuits 1

B24EC2T03: Analog Circuits 2

**Course Outcomes**

After the completion of the course the student will be able to:

|             |                                                                                                                                                                                                                    |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the structure, characteristics, configurations, and performance parameters of operational amplifiers, including applications like amplifiers, converters, and voltage followers. [Remember, Understand] |
| <b>CO 2</b> | Apply operational amplifiers in designing and analyzing various signal processing circuits such as arithmetic circuits, amplifiers, waveform shaping circuits, and filters for real-world applications. [Apply]    |
| <b>CO 3</b> | Understand the operation, types, and applications of analog multipliers and phase-locked loops (PLLs) including IC-based solutions used in modulation, detection, and synchronization.[Understand]                 |
| <b>CO 4</b> | Understand the working principles, architectures, and specifications of digital-to-analog and analog-to-digital converters, and their role in mixed-signal systems. [Understand]                                   |
| <b>CO 5</b> | Apply Op Amps and special function ICs such as 555 timers and voltage regulators to design waveform generators, timing circuits, and power management solutions. [Apply]                                           |

**Mapping of Course Outcomes With Program Outcomes**

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    |      |      |      |      |      |      |      |       | 1     |
| CO 2 | 3    | 2    | 3    | 3    | 2    |      |      |      |      |       | 2     |
| CO 3 | 3    |      |      |      | 2    |      |      |      |      |       | 2     |
| CO 4 | 3    | 2    | 2    | 2    | 2    |      |      |      |      |       | 2     |
| CO 5 | 3    | 2    | 2    | 2    | 2    |      |      |      |      |       |       |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |        | End Semester Examination |
|------------------|-----------------------|--------|--------------------------|
|                  | Test 1                | Test 2 |                          |
| Remember         | 30                    | 30     | 30                       |
| Understand       | 40                    | 40     | 40                       |
| Apply            | 30                    | 30     | 30                       |
| Analyze          |                       |        |                          |

**Mark Distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

**Continuous Internal Evaluation Pattern**

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

**End Semester Examination Pattern**

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

**SYLLABUS**



## **MODULE 1**

### **BASICS OF OPERATIONAL AMPLIFIERS**

Operational amplifiers (Op Amps): The 741 Op Amp, Block diagram, Ideal Op Amp parameters, typical parameter values for 741, equivalent circuit, DC and AC performance characteristics, slew rate, Open and closed loop configurations, voltage transfer curve, frequency response curve. Inverting Amplifier, Non-Inverting Amplifier and Differential Amplifier. Voltage Follower, V-to-I and I-to-V converters.

## **MODULE 2**

### **APPLICATIONS OF OPERATIONAL AMPLIFIERS**

Arithmetic Circuits : Design and Practical applications with an example of Adder, subtractor, Integrator, Differentiator. Instrumentation amplifier and its application for acquiring small output from wheatstone bridge using Strain gage. Logarithmic amplifier, Antilogarithmic amplifier, Comparators, Schmitt trigger, Precision rectifier- half and full wave, peak detector, clipper and clamper, Low-pass, high-pass and band-pass Butterworth filters.

## **MODULE 3**

### **ANALOG MULTIPLIER AND PLL**

Analog Multiplier using Emitter Coupled Transistor Pair - Gilbert Multiplier cell – Variable trans conductance technique, analog multiplier ICs(AD633,LM1496) and their applications, Operation of the basic PLL, Closed loop analysis, Voltage controlled oscillator, Monolithic PLL IC 565, application of PLL for AM detection, FM detection, FSK modulation and demodulation and Frequency synthesizing and clock synchronization.

## **MODULE 4**

### **ANALOG TO DIGITAL AND DIGITAL TO ANALOG CONVERTERS**

Analog and Digital Data Conversions, D/A converter – specifications - weighted resistor type, R-2R Ladder type, Voltage Mode and Current-Mode R - 2R Ladder types - switches for D/A converters, high speed sample-and-hold circuits, A/D Converters – specifications - Flash type - Successive Approximation type - Single Slope type – Dual Slope type - A/D Converter using Voltage-to-Time Conversion - Over-sampling A/D Converters, Sigma – Delta converters.

## **MODULE 5**

### **WAVEFORM GENERATORS AND SPECIAL FUNCTION IC's**

Op Amp based Astable and Monostable Multivibrators, Sine-wave generators, and Triangular wave generator, Saw-tooth wave generator. Timer IC 555, Astable and Monostable operations, Timer circuits, LED and Relay drivers.

**IC Voltage regulators** Three terminal fixed and adjustable voltage regulators - IC 723 general purpose regulator with fold back protection features- Monolithic switching regulator, Low Drop – Out(LDO) Regulators - Switched capacitor filter IC MF10, Frequency to Voltage and Voltage to Frequency converters.

### **Text Books**

1. D.Roy Choudhry, Shail Jain, “Linear Integrated Circuits”, New Age International Pvt. Ltd., 2018, Fifth Edition. (Unit I – V).
2. Sergio Franco, “Design with Operational Amplifiers and Analog Integrated Circuits”, 4th Edition, Tata Mc Graw-Hill, 2016 (Unit I – V).

### **Reference Books**

1. Ramakant A. Gayakwad, “OP-AMP and Linear ICs”, 4th Edition, Prentice Hall / Pearson Education, 2015
2. Robert F.Coughlin, Frederick F.Driscoll, “Operational Amplifiers and Linear Integrated Circuits”, Sixth Edition, PHI, 2001.
3. S.Salivahanan and V.S. Kanchana Bhaskaran, “Linear Integrated Circuits”, TMH, 2nd Edition, 4th Reprint, 2016.

## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                            | No of Lecture/Tutorial Hours |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1 (BASICS OF OPERATIONAL AMPLIFIERS)</b>                                                                                                               | 8 hours                      |
| 1.1 | 741 Operational Amplifier – Block diagram, ideal parameters, typical parameter values.                                                                           | 2 hours                      |
| 1.2 | 741 equivalent circuit, DC and AC performance characteristics, slew rate, Open and closed loop configurations, voltage transfer curve, frequency response curve. | 2 hours                      |
| 1.3 | Inverting Amplifier, Non-Inverting Amplifier and Differential Amplifier.                                                                                         | 3 hour                       |
| 1.4 | Voltage Follower, V-to-I and I-to-V converters .                                                                                                                 | 1 hour                       |
|     | <b>Module 2 (APPLICATIONS OF OPERATIONAL AMPLIFIERS)</b>                                                                                                         | 8 hours                      |
| 2.1 | Arithmetic Circuits :Design and Practical applications with an example of Adder, subtractor , Integrator,Differentiator.                                         | 2 hours                      |
| 2.2 | Instrumentation amplifier and its application for acquiring small output from wheatstone bridge.                                                                 | 2 hours                      |
| 2.3 | Logarithmic amplifier, Antilogarithmic amplifier, Comparators, Schmitt trigger .                                                                                 | 2 hours                      |
| 2.4 | Precision rectifier- half and full wave, peak detector, clipper and clamper.                                                                                     | 2 hours                      |
| 2.5 | Filtering Techniques – Low-pass, high-pass, and band-pass Butterworth filters                                                                                    | 2 hours                      |
|     | <b>Module 3 (ANALOG MULTIPLIER AND PLL )</b>                                                                                                                     | 10 hours                     |
| 3.1 | Analog Multiplier Basics – Emitter coupled transistor pair, Gilbert multiplier cell .                                                                            | 2 hours                      |
| 3.2 | Variable Transconductance Technique – Analog multiplier ICs (AD633, LM1496) and applications.                                                                    | 2 hours                      |
| 3.3 | Phase Locked Loop (PLL) Basics – Operation, closed-loop analysis                                                                                                 | 2hours                       |
| 3.4 | Voltage Controlled Oscillator (VCO) – Monolithic PLL IC 565.                                                                                                     | 2 hours                      |
| 3.5 | PLL Applications AM and FM detection, FSK modulation and demodulation, frequency synthesis, clock synchronization.                                               | 2 hours                      |
|     | <b>Module 4 (ANALOG TO DIGITAL AND DIGITAL TO ANALOG CONVERTERS )</b>                                                                                            | 10 hours                     |
| 4.1 | Introduction to A/D and D/A Conversion – Analog and digital data conversions .                                                                                   | 1 hour                       |
| 4.2 | D/A Converters – Specifications, weighted resistor type, R-2R ladder type.                                                                                       | 2 hours                      |

|     |                                                                                                                                                    |          |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 4.3 | D/A Converter Modes – Voltage mode, current-mode R-2R ladder types, switches for D/A converters.                                                   | 2 hours  |
| 4.4 | High-Speed Circuits – Sample-and-hold circuits .                                                                                                   | 1 hour   |
| 4.5 | A/D Converter Types and Specifications – Flash, successive approximation, single slope, dual slope                                                 | 2 hours  |
| 4.6 | Advanced A/D Techniques – Voltage-to-time conversion, oversampling, Sigma-Delta converters                                                         | 2 hours  |
|     | <b>Module 5 (WAVEFORM GENERATORS AND SPECIAL FUNCTION IC's )</b>                                                                                   | 10 hours |
| 5.1 | Op Amp based Astable and Monostable Multivibrators, Sine-wave generators and Triangular wave generator, Saw-tooth wave generator.                  | 2 hours  |
| 5.2 | Timer IC 555, Astable and Monostable operations, Timer circuits, LED and Relay drivers.                                                            | 2 hours  |
| 5.3 | Voltage Regulators – Three terminal fixed and adjustable voltage regulators - IC 723 general purpose regulator with fold back protection features. | 2 hours  |
| 5.4 | Switching Regulators – Monolithic switching regulators, Low Drop-Out (LDO) regulators.                                                             | 2 hours  |
| 5.5 | Special Function ICs – Switched capacitor filter IC MF10, frequency-to-voltage and voltage-to-frequency converters.                                | 2 hours  |
|     | <b>Total Hours</b>                                                                                                                                 | 48 Hours |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. What are the ideal characteristics of an op-amp.?
2. Define Slew rate?
3. Draw equivalent circuit of 741 and bring out the DC and AC performance characteristics.
4. Draw and explain the circuit of a voltage to current converter with grounded load and derive its transfer function.

#### Course Outcome 2 (CO 2):

1. State how practical integrator is different from simple integrator circuit, with relevant sketches.

2. What are the advantages of active filters over passive filters?
3. Design the circuits to obtain the following output,  $V_o$ . (i)  $V_o = (5V_1)$  (ii)  $V_o = V_1 + 2V_2$  (iii)  $V_o = -(V_1 + V_2 + V_3)$  (iv)  $V_o = -2V_1 - 5V_2$
4. D4. Analyze a Butterworth High pass filter and explain its working.

**Course Outcome 3 (CO 3):**

1. Explain the principle of operation of an analog multiplier IC.
2. How does AD633 function in signal processing applications?.
3. Explain the operation of PLL. What is its lock range and capture range.
4. Bring out the application of PLL in FSK modulation and demodulation.

**Course Outcome 4 (CO 4):**

1. Draw and explain the working of successive approximation type ADC.
2. Draw and explain the working of successive approximation type ADC.
3. Explain the circuit of a 4-bit R-2R ladder DAC.
4. Explain the working of a weighted resistor type DAC. Mention its drawbacks.

**Course Outcome 5 (CO 5):**

1. List the features of Timer IC 555.
2. Draw the internal diagram of a 555 timer and explain its working as a monostable multivibrator and derive the expression for its pulse-width.
3. Design a free-running multivibrator using 555 for a frequency of 1 KHz and duty cycle of 60%. Choose  $C = 0.1 \text{ F}$ .
4. List out DAC specifications.



MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

FOURTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2025

**Course Code: B24EC2T06**

**Course Name: LINEAR INTEGRATED CIRCUITS**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks.**

1. Find the maximum possible frequency, without distortions, for a sine wave of voltage 10V peak to peak with an op-amp whose slew rate is 10V/ s.
2. Draw the equivalent circuit of the Op-Amp and explain the voltage transfer characteristics.
3. Design the op-amp circuits to obtain the following outputs: a)  $V_o = 5V_{in}$  b)  $V_o = V_1 + 2V_2$
4. State how a practical differentiator circuit differs from a simple integrator circuit, with relevant sketches.
5. What is the significance of the timing capacitor and resistor values in the NE 565 circuit?.
6. What is frequency synthesizing, and why is it important in communication systems?
7. Find the resolution and dynamic range of a digital-to-analog converter, if the maximum peak-to-peak output voltage is 5V and the input signal is a 10-bit word.
8. Give the specifications of Analog to Digital converter.
9. Design a voltage regulator using IC 723 for an output voltage of 6V and a current of 1A. Assume  $V_{ref} = 7V$ .
10. Design a monostable multivibrator using 555 to get a pulse width of 2ms.



**PART B**

**Answer any one question from each module. Each question carries 14 marks.**

1. (a) Differentiate between the open loop configurations of inverting and non-inverting amplifiers. (4 marks)
- (b) Analyse differential amplifier for i) Closed loop voltage gain ii) Input resistance iii) Output resistance. (10 marks)

**OR**

2. (a) Draw the circuit of the non-inverting amplifier and derive the following characteristics i) Closed loop voltage gain ii) Input resistance iii) Output resistance. (8 marks)
- (b) Explain Voltage to Current converter with grounded load. (6 marks)
3. (a) Draw the circuit of an ideal integrator using op-amp and derive the expression for output voltage. Discuss the drawbacks of this circuit and explain how it is rectified in a practical integrator. (8 marks)
- (b) Design a Schmitt Trigger circuit using an op-amp with UTP = 4 V and LTP -3 V. Output saturation voltages are  $\pm 13$  V. (6 marks)

**OR**

4. (a) Design a Butterworth active high pass filter for a cut-off frequency of 10 kHz with a stop band attenuation of -40dB/decade. (7 marks)
- (b) Draw the circuit diagram of the basic log amplifier and derive the expression for output voltage. (7 marks)
5. (a) Why is the Gilbert Multiplier Cell important in communication systems? (4 marks)
- (b) Explain the application of NE565 as FSK modulator. (10 marks)

**OR**

6. (a) Explain the working of VCO with relevant diagrams. (8 marks)
- (b) What role do analog multipliers play in automatic gain control (AGC) circuits? (6 marks)
7. (a) An 8-bit DAC produces an output voltage of 2 V for a binary input of 0110 0100. Find the output voltage for a binary input of 1011 0011. (8 marks)
- (b) Why are Sigma-Delta converters preferred for high-resolution applications? (6 marks)

**OR**

8. (a) With the help of a circuit diagram, explain the working of a binary weighted resistor DAC. (7 marks)
- (b) Design Flash type ADC and explain its working. (7 marks)

9. (a) Using the internal diagram of NE555 IC, explain the working of a symmetric astable multivibrator circuit.

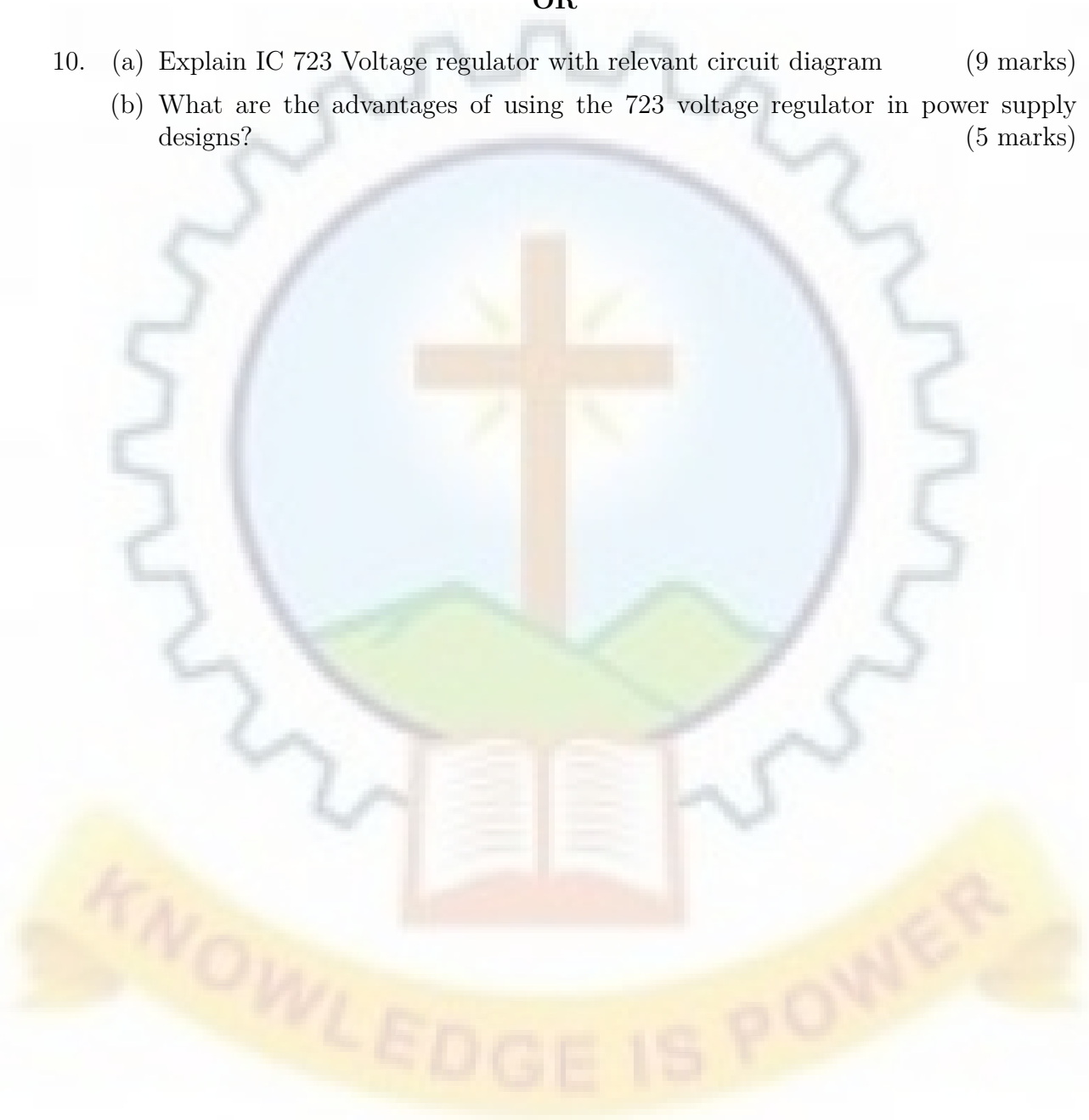
(9 marks)

- (b) How does a switched capacitor filter like the MF10 differ from an analog filter?  
(5 marks)

**OR**

10. (a) Explain IC 723 Voltage regulator with relevant circuit diagram (9 marks)

- (b) What are the advantages of using the 723 voltage regulator in power supply designs?  
(5 marks)



| B24HU2T02 | ENTREPRENEURSHIP<br>AND MANAGEMENT<br>SKILLS FOR ENGINEERS | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|------------------------------------------------------------|---|---|---|---|--------|-------------------------|
|           |                                                            | 2 | 1 | 0 | 4 |        |                         |

**Preamble**

In today's rapidly evolving world, engineers must go beyond technical expertise and develop entrepreneurial, managerial, and business acumen to drive innovation and create impact. This course equips students to identify opportunities, develop scalable business models, and apply modern management and marketing strategies. Through activity-based learning, case studies, and real-world problem-solving, students will gain practical insights into leadership, business analysis, and intellectual property rights (IPR), preparing them for startups, corporate leadership, and innovation-driven industries.

**Prerequisites**

Nil.

**Course Outcomes**

By the end of this course, students will be able to:

|             |                                                                                                                                                                               |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand key principles and functions of management to grasp modern managerial roles (Cognitive Knowledge Level: Understand)                                                |
| <b>CO 2</b> | Explain the fundamentals of managing people and processes through effective staffing, motivation, leadership, and control strategies. (Cognitive Knowledge Level: Understand) |
| <b>CO 3</b> | Apply modern marketing strategies and digital transformation to build sustainable businesses. (Cognitive Knowledge Level: Apply)                                              |
| <b>CO 4</b> | Understand the basics of idea pitching, managing finances and using modern marketing tools. (Cognitive Knowledge Level: Understand)                                           |
| <b>CO 5</b> | Understand Intellectual Property Rights (IPR) and legal frameworks to protect innovation and navigate startup challenges. (Cognitive Knowledge Level: Understand)             |

**Mapping of Course Outcomes With Program Outcomes**

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 |      |      |      |      |      | 1    | 1    | 1    | 1    | 2     | 2     |
| CO 2 |      |      |      |      |      | 1    | 1    | 2    | 2    | 2     | 2     |
| CO 3 |      |      |      |      |      |      |      |      |      | 3     | 2     |
| CO 4 |      |      |      |      |      |      |      |      |      | 2     | 2     |
| CO 5 |      |      |      |      |      | 1    |      |      | 1    | 2     | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 40                    | 30              | 30                                 |
| Understand       | 60                    | 50              | 50                                 |
| Apply            |                       | 20              | 20                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1 (6 hours)

**Functions of Management:** Introduction to Management: Definitions and scope - Core Functions - Levels of Management - Evolution of Management Thought: Scientific Management (F.W. Taylor), Administrative Management (Henri Fayol), Modern Approaches - Planning and Types of Plans - Organizational Structures: Departmentalization.

### MODULE 2 ( 7 hours)

**Manpower Planning, Leadership & Control:** Staffing - Motivation Theories – Leadership - Understanding Negotiation in Leadership: Types of Negotiation – Barriers to effective communication - Activity-based learning.

### MODULE 3 (7 hours)

**Entrepreneurial Thinking & Business Design:** Entrepreneurial Mindset: Growth mindset, risk-taking, and decision-making - Finding a Good Business Idea - How to prepare an Empathy canvas, Value proposition canvas and Idea canvas - Digital Business Models: Freemium, Subscription, Platform-based - Business Model Canvas: Develop and visualise the business model.

### MODULE 4 (8 hours)

**Startup Pitching, Marketing & Financials:** Startup Financials: Revenue models, cost structure, funding stages, valuation basics - Investor Pitching: Structure of a pitch deck, communicating value, funding strategy - Digital branding, social media, performance marketing - Growth Strategies: Network effects, influencer marketing, CRM tools.

### MODULE 5 (8 hours)

**Intellectual Property Rights (IPR) and Legal Framework** Overview of Intellectual Property Rights (IPR) - Product patents, Process patents- Prerequisites for filing a patent: Novelty, Inventive step, Industrial applicability -Provisional vs Complete application - Common mistakes to avoid before filing - Anatomy of a Patent Document - Overview of databases - Legal Aspects of Startups- Business Registrations and Legal structures – Compliance & Regulatory Requirements.

## **Reference Books**

1. Ricky W. Griffin, Jean M. Phillips & Stanley M. Gully, *Organizational Behavior: Managing People and Organizations*, Cengage Learning, 12th Edition, 2019.
2. Stephen P. Robbins & Timothy A. Judge, *Organizational Behavior*, Pearson Education, 18th Edition, 2019.
3. Heidi M. Neck, Christopher P. Neck & Emma L. Murray, *Entrepreneurship: The Practice and Mindset*, SAGE Publications Inc., 3rd Edition, 2023.
4. Alejandro Cremades, *The Art of Startup Fundraising: Pitching Investors, Negotiating the Deal, and Everything Else Entrepreneurs Need to Know*, Wiley, 2023.
5. Dr R. Radhakrishnan & Dr S. Balasubramanian, *Intellectual Property Rights: Text and Cases*, Excel Books, 2008.



**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                                                                                                                                      | <b>No of Lec-<br/>ture/Tuto-<br/>rial Hours</b> |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|
|           | <b>Module 1</b>                                                                                                                                                                                                                   | <b>6</b>                                        |
| 1.1       | Introduction to Management: Definitions and scope - Core Functions: Planning, Organizing, Staffing, Directing, Controlling. - Levels of Management: Top, Middle, Lower.                                                           | 1                                               |
| 1.2       | Evolution of Management Thought: Classical approaches -F.W. Taylor, Henri Fayol - Modern Approaches: Systems approach, Contingency approach.                                                                                      | 1                                               |
| 1.3       | Planning: Importance and steps in planning (objectives, alternatives, evaluation, selection). Types of plans: Strategic, Tactical, Operational, Contingency.                                                                      | 2                                               |
| 1.4       | Organizational Structure, Types of Organizational Structures: Functional, Divisional, Matrix, Flat vs. Tall Organizations, Impact of Structure on Business Operations.                                                            | 2                                               |
|           | <b>Module 2</b>                                                                                                                                                                                                                   | <b>7</b>                                        |
| 2.1       | Manpower Planning, Job Analysis, Recruitment vs Selection - Motivation Theories: Maslow's Hierarchy of Needs, Herzberg's Two-Factor Theory.                                                                                       | 2                                               |
| 2.2       | Leadership theories: Theory X and Theory Y- Leadership Styles: Autocratic, Democratic, Laissez-faire - Application and effectiveness in various organizational contexts.                                                          | 2                                               |
| 2.3       | Understanding Negotiation in Leadership: Types of Negotiation: Distributive vs. Integrative, Understanding when to compete and when to collaborate. Team building.                                                                | 2                                               |
| 2.4       | Communication Types: Formal and Informal - Barriers to effective communication. Communication distortion. Case studies.                                                                                                           | 1                                               |
|           | Activity-Based Learning: Leadership Roll Playing Simulation: Real-life negotiation scenarios such as investor discussions or conflict resolution between co-founders to practice persuasive communication and strategic thinking. |                                                 |
|           | <b>Module 3</b>                                                                                                                                                                                                                   | <b>7</b>                                        |
| 3.1       | Entrepreneurial Mindset – Growth mindset, risk-taking, and decision-making.                                                                                                                                                       | 1                                               |
| 3.2       | Finding a Good Business Idea - Looking around for real-life problems people face. How to prepare an Empathy canvas, value proposition canvas and Idea canvas.                                                                     | 2                                               |
| 3.3       | Planning Your Business on One Page - Use a simple chart called the Business Model Canvas.                                                                                                                                         | 2                                               |

|     |                                                                                                                                                                                                                                                        |                 |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 3.4 | How Online Businesses Make Money - Freemium Model (Free basic version, pay for extra features) - Subscription Model (Monthly/Yearly payments for continuous use) - Platform Model (Connecting buyers and sellers, like Amazon or Swiggy).              |                 |
|     | Activity: The students may be encouraged to make a Business model plan of their choice.                                                                                                                                                                |                 |
|     | <b>Module 4</b>                                                                                                                                                                                                                                        | <b>6</b>        |
| 4.1 | Startup financials - Key Financial Terms: Revenue, cost, profit, cash flow, gross margin, net profit, burn rate, turnover, ask - Types of Revenue Models, cost structure, funding stages, valuation basics.                                            | 2               |
| 4.2 | Investor Pitching – Structure of a pitch deck, communicating value, and funding strategy.                                                                                                                                                              | 2               |
| 4.3 | Modern Marketing – Digital branding, social media, performance marketing - Growth Strategies: Network effects, influencer marketing, CRM tools.                                                                                                        | 2               |
|     | <b>Module 5</b>                                                                                                                                                                                                                                        | <b>9</b>        |
| 5.1 | Overview of Intellectual Property Rights (IPR) - What is a patent and why does it matter - Types of patentable subject matter: Product Patents, Process Patents- Prerequisites for filing a patent: Novelty, Inventive step, Industrial applicability. | 2               |
| 5.2 | Provisional vs Complete application - When to file a patent (timing strategy for start-ups) - Common mistakes to avoid before filing (e.g., disclosing ideas publicly)                                                                                 | 1               |
| 5.3 | Anatomy of a Patent Document: Title, Abstract, Background, Claims, Drawings - Indian vs International Patents: Filing paths and differences (PCT vs national phase) - Overview of databases: Google Patents, USPTO, WIPO, Espacenet                    | 2               |
| 5.4 | Business Registrations & Legal Structures - Types of business entities: Sole Proprietorship, Partnership, LLP, Private Ltd, OPC. Startup India Registration – Benefits & Eligibility.                                                                  | 2               |
| 5.5 | Compliance & Regulatory Requirements - GST Registration, ROC Filings. Startup Taxation & Incentives. Taxes applicable to startups (Income Tax, GST, TDS, Angel Tax). Tax Benefits for Startups under Section 80-IAC & DPIIT.                           | 2               |
|     | <b>Total Hours</b>                                                                                                                                                                                                                                     | <b>35 Hours</b> |

## CO ASSESSMENT QUESTIONS

**Course Outcome 1 (CO 1):**

1. Explain the core functions of management and how they support effective organizational operations.
2. How do different levels of management (top, middle, lower) contribute to achieving business goals?
3. Explain the difference between classical and modern approaches to management thought.

**Course Outcome 2 (CO 2):**

1. How do Maslow's Hierarchy of Needs and Herzberg's Two-Factor theory explain employee motivation in the workplace?
2. Enumerate the key differences between Theory X, Theory Y, and Theory Z, and how they influence leadership styles.
3. How do BATNA and ZOPA help leaders make effective negotiation decisions during team conflicts or business deals?

**Course Outcome 3 (CO 3):**

1. Use the Business Model Canvas to design a simple online learning platform. Include key elements such as customer segments, revenue model, and value proposition.
2. Prepare an Idea Canvas for a mobile app that helps local farmers sell directly to customers. Explain how this solution fits a real-world problem.
3. Choose one digital business model (freemium, subscription, or platform-based) and apply it to a startup idea of your choice. Explain how this model supports long-term business sustainability.

**Course Outcome 4 (CO 4):**

1. Explain the key components of a startup pitch deck and their role in communicating value to investors.
2. Describe the difference between a revenue model and a cost structure, and why both are important in startup financial planning.
3. What is digital branding, and how can tools like social media and influencer marketing help a new business grow?

**Course Outcome 5 (CO 5):**

1. Discuss the key differences between product patents and process patents.
2. Explain the basic prerequisites for filing a patent.
3. List any three types of legal business structures in India and describe how choosing the right structure supports startup compliance.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 2**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FORTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 202**

**Course Code: B24HU2T02**

**Course Name: ENTREPRENEURSHIP AND MANAGEMENT SKILLS FOR ENGINEERS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define the core functions of management with a brief explanation.
2. Differentiate between flat and tall organisational structures.
3. Explain the key difference between Maslow's and Herzberg's motivation theories.
4. Differentiate between distributive and integrative negotiation with one example each.
5. List any three key components of the Business Model Canvas and explain their purpose.
6. Explain the concept of a growth mindset in the context of entrepreneurship.
7. State the meaning of 'burn rate' and why it is important for startups.
8. Mention any two components of a startup pitch deck and explain their importance.
9. State the difference between a provisional and a complete patent application.
10. List any two legal compliance requirements for a startup after registration.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

- 11 a. Illustrate the three levels of management with suitable examples and describe the role of each in organizational decision-making. (7)
- b. Discuss the different types of plans (strategic, tactical, operational, contingency) with examples, and explain how they guide managerial actions. (7)

(OR)

- 12 a. Explain the five core functions of management and discuss their importance in running a business efficiently. (7)
- b. Compare the classical management theories of F.W. Taylor and Henri Fayol with modern approaches like systems and contingency theory. (7)

**Module II**

- 13 a. Describe Herzberg's Two-Factor Theory and Maslow's Hierarchy of Needs. How can managers apply them to motivate employees? (7)
- b. Explain the steps involved in manpower planning and differentiate between recruitment and selection with examples. (7)

(OR)

- 14 a. You are leading a startup team facing internal disagreements. Explain how different types of negotiation and leadership styles can help resolve the conflict. (7)
- b. Discuss the impact of communication barriers on leadership effectiveness and provide examples of how leaders can overcome them. (7)

**Module III**

- 15 a. Imagine you've identified a problem faced by college students — difficulty in finding affordable and quality food near campus. How would you use an Idea Canvas to shape a possible business solution? (7)
- b. You are building a mobile app that alerts users about air quality levels in real time. Using an Empathy Canvas, explain how you would understand the daily experience of urban commuters who are your target users. (7)

(OR)

- 16 a. A team of students has developed a low-cost, portable device to detect water leakage in household plumbing systems. Using the Value Proposition Canvas, explain how this solution fits the needs of middle-income homeowners. (7)
- b. A startup team has developed a low-cost solar-powered drying solution to help small-scale agricultural producers reduce post-harvest losses. Using the Business Model Canvas, outline their customer segments, key partners, and value proposition. (7)

**Module IV**



- 17 a. A product-based startup is working on modular housing solutions designed for quick deployment in disaster-hit regions. Describe how the team can develop a strong investor pitch focusing on revenue model, scalability, and social impact. (7)
- b. A D2C (Direct-to-Consumer) skincare brand is looking to expand via digital platforms. Explain how influencer marketing and CRM tools can be integrated to build customer loyalty and drive conversions. (7)

(OR)

- 18 a. A new mobile app startup wants to attract early investors. Explain the importance of understanding financial terms such as revenue, burn rate, and valuation when preparing for funding. Use simple examples to support your answer. (7)
- b. A startup developing a wearable health monitoring device is preparing to pitch to early-stage investors. Outline the essential components that should be included in their pitch deck. (7)

**Module V**

- 19 a. A startup has created a catchy logo and app interface. Explain which types of IPR they need to protect and why each is important. (7)
- b. You have developed a unique cooling technology for electric bikes. Describe the steps you would follow to file a patent in India and explain how it helps protect your innovation. (7)

(OR)

- 20 a. Compare three common legal structures available for startups in India. For a tech-based service startup, which would you recommend and why? (7)
- b. What are the key tax benefits offered under the Startup India Scheme and Section 80-IAC? How do these help early-stage startups survive financially? (7)



| <b>B24EC2T07</b> | <b>FPGA BASED<br/>SYSTEM DESIGN</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF<br/>INTRODUCTION</b> |
|------------------|-------------------------------------|----------|----------|----------|----------|---------------|---------------------------------|
|                  |                                     | 2        | 1        | 0        | 4        |               |                                 |

**Preamble**

This course offers an overview of Verilog HDL-based design, FPGA architecture, RT-level combinational and sequential circuits, FSM design, and FSM/D applications for digital system implementation.

**Prerequisites**

B24EC1T03 : LOGIC CIRCUIT DESIGN

**Course Outcomes**

After the completion of the course the student will be able to:

|             |                                                                                                                                                                                                                                                                                                                    |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Upon completing this course, students will be able to understand and apply Verilog HDL for designing gate-level combinational circuits, develop structural descriptions, create testbenches, and gain a foundational understanding of FPGA devices and EDA software for digital system design. [Understand, Apply] |
| <b>CO 2</b> | Upon completing this course, students will be able to design RT-level combinational circuits using Verilog, effectively utilize operators, always blocks, conditional statements, and parameters, while following best coding practices and implementing design examples. [Understand, Apply]                      |
| <b>CO 3</b> | Upon completing this course, students will be able to design and implement RT-level regular sequential circuits using Verilog, including flip-flops, registers, and testbenches, with applications such as shift registers, counters, PWM generators, and LED time-multiplexing circuits. [Understand, Apply]      |
| <b>CO 4</b> | Upon completing this course, students will be able to design and implement Finite State Machines (FSM) using Verilog, including Mealy and Moore models, and apply them in practical examples such as edge detectors, debounce circuits, and parking lot occupancy counters. [Understand, Apply]                    |
| <b>CO 5</b> | Upon completing this course, students will be able to design and implement FSM/Ds using ASMD charts and Verilog, develop code with explicit data path components, and apply them to practical design examples such as Fibonacci circuits, division circuits, and low-frequency counters. [Understand, Apply]       |

**Mapping of Course Outcomes With Program Outcomes**

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| CO 2 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| CO 3 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| CO 4 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| CO 5 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Verilog HDL – based design, Overview of FPGA and EDA software:** Introduction, General description, Basic lexical elements and data types, Data types, Program skeleton, Structural description, Gate-level combinational circuit, Testbench, Introduction and overview of a general FPGA device, Gate-level greater-than circuit, Gate-level binary decoder.

### MODULE 2

**RT-level combinational circuits:** Introduction, Operators, always block for a combinational circuit, if statement, Case statement, General coding guidelines for an always block, Parameter and constant, Design examples.

### MODULE 3

**RT-level regular sequential circuits:** Introduction to Regular Sequential Circuit, HDL code of the FF and register, Test bench for sequential circuits, Design examples: shift register, Binary counters. Testbench for sequential circuits, Case study: LED time-multiplexing circuit, Stopwatch, Programmable square-wave generator, PWM and LED dimmer, Rotating LED banner circuit.

### MODULE 4

**FSM:** Introduction, FSM representation and code development, Mealy and Moore outputs, Design examples: Rising-edge detector, Debouncing circuit, Testing circuit, Case study: Dual-edge detector Alternative debouncing circuit, Parking lot occupancy counter.

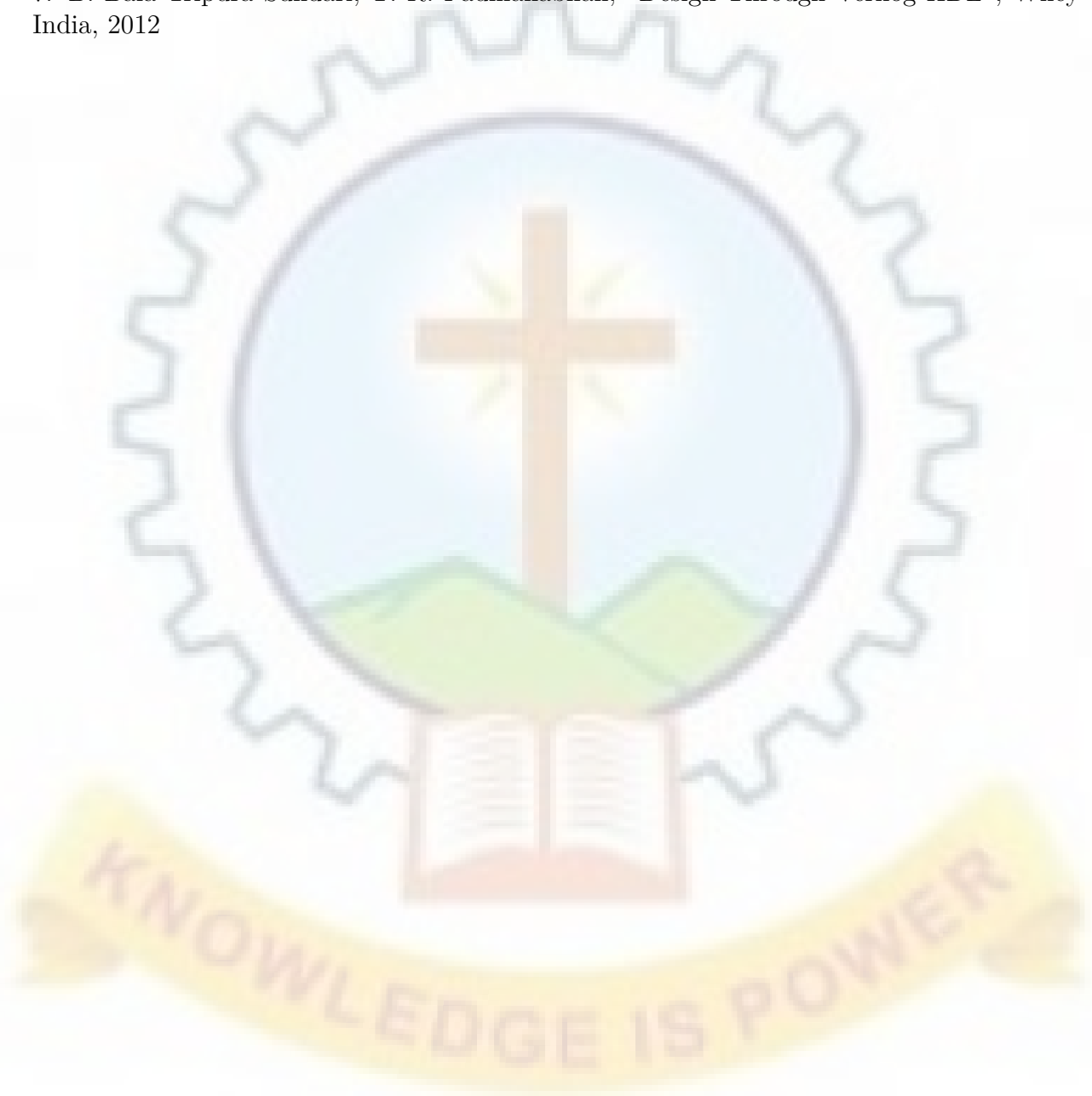
### MODULE 5

**FSMD:** Introduction, ASMD chart, Code development of an FSMD, Debouncing circuit based on RT methodology, Code with explicit data path components, Testing circuit, Design examples: Fibonacci number circuit, Division circuit, Binary-to-BCD conversion circuit, Period counter, Accurate low-frequency counter.

### Text Books

1. Pong P. Chu, FPGA Prototyping by Verilog Examples, John Wiley & Sons, 2008

2. FPGA-Based System Design –Wayne Wolf, Prentice Hall
3. Modern VLSI Design: System-on-Chip Design (3rdEdition)Wayne Wolf
4. Field Programmable Gate Array Technology - S. Trimberger, Edr,1994, Kluwer Academic
5. Digital Design Using Field Programmable Gate Array, P.K. Chan & S. Mourad, 1994, Prentice Hall
6. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", Second Edition, Prentice Hall PTR, 2003
7. B. Bala Tripura Sundari, T. R. Padmanabhan, "Design Through Verilog HDL", Wiley India, 2012



**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                                                                                                                  | No of Lecture/Tutorial Hours |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                        | <b>10</b>                    |
| 1.1 | Verilog HDL – based design, Overview of FPGA and EDA software: Introduction, General description.                                                      | 2                            |
| 1.2 | Basic lexical elements and data types.                                                                                                                 | 1                            |
| 1.3 | Data types, Program skeleton, Structural description.                                                                                                  | 2                            |
| 1.4 | Gate-level combinational circuit, Testbench.                                                                                                           | 2                            |
| 1.5 | Introduction and overview of a general FPGA device, Gate-level greater-than circuit, Gate-level binary decoder.                                        | 3                            |
|     | <b>Module 2</b>                                                                                                                                        | <b>9</b>                     |
| 2.1 | RT-level combinational circuits: Introduction, Operators.                                                                                              | 2                            |
| 2.2 | Always block for a combinational circuit.                                                                                                              | 1                            |
| 2.3 | If statement, Case statement.                                                                                                                          | 1                            |
| 2.4 | General coding guidelines for an always block, Parameter and constant.                                                                                 | 1                            |
| 2.5 | Design examples.                                                                                                                                       | 4                            |
|     | <b>Module 3</b>                                                                                                                                        | <b>10</b>                    |
| 3.1 | RT-level Regular sequential circuits: Introduction to Regular Sequential Circuit, HDL code of the FF and register, Test bench for sequential circuits. | 2                            |
| 3.2 | Design examples: shift register, Binary counters. Test-bench for sequential circuits.                                                                  | 4                            |
| 3.3 | Case study: LED time-multiplexing circuit, Stopwatch.                                                                                                  | 2                            |
| 3.4 | Programmable square-wave generator, PWM and LED dimmer, Rotating LED banner circuit.                                                                   | 2                            |
|     | <b>Module 4</b>                                                                                                                                        | <b>8</b>                     |
| 4.1 | FSM: Introduction, FSM representation and code development.                                                                                            | 2                            |
| 4.2 | Mealy and Moore outputs.                                                                                                                               | 1                            |
| 4.3 | Design examples: Rising-edge detector, Debouncing circuit, Testing circuit.                                                                            | 2                            |
| 4.4 | Case study: Dual-edge detector Alternative debouncing circuit, Parking lot occupancy counter.                                                          | 3                            |
|     | <b>Module 5</b>                                                                                                                                        | <b>8</b>                     |
| 5.1 | FSMD-Introduction, ASMD chart.                                                                                                                         | 2                            |
| 5.2 | Code development of an FSMD, Debouncing circuit based on RT methodology.                                                                               | 1                            |
| 5.3 | Code with explicit data path components, Testing circuit.                                                                                              | 1                            |
| 5.4 | Design examples: Fibonacci number circuit, Division circuit, Binary-to-BCD conversion circuit, Period counter, Accurate low-frequency counter.         | 4                            |

|  |                    |                 |
|--|--------------------|-----------------|
|  | <b>Total Hours</b> | <b>45 Hours</b> |
|--|--------------------|-----------------|

## CO ASSESSMENT QUESTIONS

### Course Outcome 1 (CO 1):

1. Design a gate-level combinational circuit in Verilog that implements a 4-bit binary greater-than comparator. Include a testbench to verify the functionality of the circuit. Explain the process of simulation and results interpretation.
2. Write a Verilog program to create a 3-to-8 binary decoder using structural description. Discuss the FPGA architecture and how this design can be implemented on a general FPGA device. Include the necessary testbench to validate the design.

### Course Outcome 2 (CO 2):

1. Design a 4-bit binary multiplier using RT-level combinational logic in Verilog. Use the always block for the design and include appropriate use of operators, constants, and parameters. Provide a testbench to verify the correctness of your design.
2. Write a Verilog code for a 4-to-1 multiplexer using the case statement inside an always block. Explain the use of the if and case statements for conditional logic, and include a testbench to check the functionality of the multiplexer.

### Course Outcome 3 (CO 3):

1. Design a 4-bit shift register using RT-level sequential logic in Verilog. Implement the HDL code for the flip-flops (FF) and register, and provide a testbench to simulate and verify the functionality of the shift register.
2. Write a Verilog program to design a PWM (Pulse Width Modulation) generator that controls the brightness of an LED. Include a testbench to validate the PWM waveform and its effect on the LED dimming functionality.

### Course Outcome 4 (CO 4):

1. Design a rising-edge detector using an FSM in Verilog. Implement the FSM with a Mealy or Moore output model and provide the necessary testbench to validate its functionality. Explain the design and simulation results.



2. Develop a parking lot occupancy counter using a Moore FSM model in Verilog. The counter should increment when a car enters and decrement when a car leaves. Provide a testbench to verify the behavior of the parking lot counter and discuss the FSM implementation details.

**Course Outcome 5 (CO 5):**

1. Design an FSMD (Finite State Machine with Data path) for generating Fibonacci numbers in Verilog. Use an ASMD chart for representation, and include the code development with explicit data path components. Provide a testbench to validate the Fibonacci sequence generation.
2. Implement a binary-to-BCD (Binary Coded Decimal) converter using an FSMD model in Verilog. Use the ASMD chart for planning the design, and provide the Verilog code with explicit data path components. Include a testbench to verify the accuracy of the binary-to-BCD conversion.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FORTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2024**

**Course Code: B24EC2T07**

**Course Name: FPGA BASED SYSTEM DESIGN**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Explain the concept of structural description in Verilog HDL. How does it differ from behavioral description?
2. Provide an overview of a general FPGA device.
3. What are the different logical, arithmetic, and relational operators used in Verilog for combinational circuit design?
4. Explain how the case statement is used in Verilog for designing combinational circuits.
5. What is the role of flip-flops in sequential circuit design?
6. Write Verilog HDL code for a D flip-flop and explain its working.
7. Differentiate between Mealy and Moore FSMs.
8. Explain the concept of FSM representation using a state diagram.
9. What is an FSM D, and how does it differ from a standard FSM?
10. Explain the importance of explicit data path components in FSM D design.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Design a gate-level binary decoder in Verilog for a 3-bit input. Explain the logic behind the design and show the Verilog code. (7)  
b) Write Verilog code for a gate-level greater-than (>) circuit for two 4-bit inputs. Include the complete code and explain its functionality. (7)
12. a) Describe the basic lexical elements and data types in Verilog HDL. Provide examples of each and explain their usage. (7)  
b) What is a testbench in Verilog HDL? Describe its role in verifying a digital design and provide an example of a simple testbench. (7)

**Module II**

13. a) What is the purpose of using parameters and constants in Verilog? Give an example of how parameters can be used to design a parameterized 4-bit adder. (7)  
b) Design a 4-bit binary subtractor using Verilog. Use the always block and appropriate operators for the design and explain your approach. (7)
14. a) Write Verilog code for a 3-to-8 binary decoder using the case statement in an always block. Provide a detailed explanation of the code and its working. (7)  
b) What are the general coding guidelines for writing an always block in Verilog? Discuss best practices to avoid common pitfalls such as latches and incomplete sensitivity lists. (7)

**Module III**

15. a) Write Verilog code for a programmable square-wave generator. Explain how the frequency of the output wave can be controlled. (7)  
b) What is Pulse Width Modulation (PWM)? Design a PWM generator in Verilog to control the brightness of an LED. (7)
16. a) Write Verilog code for a binary counter that increments every clock cycle. Explain the significance of synchronous and asynchronous resets in the design. (7)  
b) What is a testbench in the context of sequential circuits? Explain its purpose and provide an example of a testbench for a 4-bit binary counter. (7)

**Module IV**

17. Explain the design of a parking lot occupancy counter using an FSM. Provide the state diagram, Verilog code, and testbench for implementation. (14)
18. Design a debouncing circuit using a Moore FSM model in Verilog. Explain how it eliminates signal noise and provide a testbench to validate the design. (14)

**Module V**

19. Write Verilog code for a Fibonacci number generator using an FSM. Include the ASM chart and explain the implementation. (14)
20. What is binary-to-BCD conversion? Design an FSM for this conversion and explain its working using an ASM chart and Verilog code. (14)



| B24EC2L05 | MICROCON-<br>TROLLER LAB | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|--------------------------|---|---|---|---|--------|-------------------------|
|           |                          | 0 | 0 | 3 | 2 | 2      | 2024                    |

**Preamble**

The aim of the course is to provide hands-on experience to the learners on microcontroller programming and interface design. This course helps the learners to enhance their capability to design and implement various embedded systems for real-world problems.

**Prerequisite**

B24EC1T03 : LOGIC CIRCUIT DESIGN

**Course Outcomes**

After the completion of the course the student will be able to

|             |                                                                                                             |
|-------------|-------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Master 8051 Programming in Assembly language and C language (Cognitive Knowledge Level: Understand, Apply)  |
| <b>CO 2</b> | Implement Timer and Counter for various time base operations (Cognitive Knowledge Level: Understand, Apply) |
| <b>CO 3</b> | Develop Interrupt-Based Systems for real time operations (Cognitive Knowledge Level: Understand, Apply)     |
| <b>CO 4</b> | Interface and Control External Peripherals (Cognitive Knowledge Level: Understand, Apply, Analyse)          |
| <b>CO 5</b> | Design and Prototype Embedded Applications (Cognitive Knowledge Level: Understand, Apply, Analyse)          |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| <b>CO 1</b> | 3   | 2   | 2   | 2   | 1   |     |     |     |     |      | 2    |
| <b>CO 2</b> | 3   | 2   | 2   | 2   | 2   |     |     |     |     |      | 2    |
| <b>CO 3</b> | 3   | 2   | 2   | 2   | 2   |     |     |     |     |      | 2    |
| <b>CO 4</b> | 3   | 2   | 2   | 2   | 3   |     |     |     |     |      | 2    |
| <b>CO 5</b> | 3   | 3   | 3   | 3   | 3   | 1   | 1   | 3   | 2   | 2    | 3    |

**Mark Distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hour       |

**Continuous Internal Evaluation Pattern**

|                       |          |
|-----------------------|----------|
| Attendance            | 10 marks |
| Continuous Assessment | 20 marks |
| Internal Test         | 15 marks |
| Lab Record            | 5 marks  |

**End semester Examination pattern**

|                                |          |
|--------------------------------|----------|
| Preliminary Work               | 30 marks |
| Performance and Implementation | 20 marks |
| Result and Inference           | 30 marks |
| Viva                           | 20 marks |

**SYLLABUS****LIST OF EXPERIMENTS**

|           |                                                                                                                                                                                                                                       |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>1</b>  | Familiarization with 8051 Development Tools: Study of hardware (8051 development kit) and software (Keil, Proteus, etc.), Setting up the simulation and debugging environment.                                                        |
| <b>2</b>  | Basic Assembly Language Programs: Program to transfer data between registers and memory, Program for arithmetic operations (addition, subtraction, multiplication, division), Logical operations (AND, OR, XOR) and bit manipulation. |
| <b>3</b>  | Timer-Based Delay Generation: Programming Timer 0 and Timer 1 in different modes, Generate delays and measure event frequencies.                                                                                                      |
| <b>4</b>  | Event Counting Using Counters: Configure counters for counting external pulses.                                                                                                                                                       |
| <b>5</b>  | Interrupt Programming: Implement external and timer-based interrupts, Prioritize interrupts and handle multiple interrupts.                                                                                                           |
| <b>6</b>  | Serial Communication: Program UART for data transmission and reception, Interfacing 8051 with PC for serial communication.                                                                                                            |
| <b>7</b>  | LED and Switch Interfacing: Control LEDs using switches and microcontroller logic.                                                                                                                                                    |
| <b>8</b>  | Seven-Segment Display Interfacing: Program 8051 to display numbers on a 7segment display using multiplexing mode                                                                                                                      |
| <b>9</b>  | Keypad Interfacing: Write a program to detect keypresses and display corresponding outputs.                                                                                                                                           |
| <b>10</b> | LCD Interfacing: Program to display custom messages on an LCD module.                                                                                                                                                                 |
| <b>11</b> | Interface an ADC chip to 8051 to read analog signals                                                                                                                                                                                  |
| <b>12</b> | Interface a DAC IC to generate analog waveforms.                                                                                                                                                                                      |



|           |                                                                                                    |
|-----------|----------------------------------------------------------------------------------------------------|
| <b>13</b> | Stepper Motor Interfacing: Program the 8051 to control the direction and steps of a stepper motor. |
| <b>14</b> | DC Motor Interfacing: Implement speed and direction control using PWM                              |
| <b>15</b> | Servo Motor Interfacing: Control speed, direction and angle of rotation using PWM.                 |

### Reference Books

1. Datasheet, 8051 Hardware Description, Intel Corporation, 1992
2. Lyla B. Das, Microprocessors and Microcontrollers, Pearson Education, 2011
3. Steve Furber, ARM System-on-Chip Architecture, Addison-Wesley Educational Publishers Inc, 2000
4. Joseph Yiu, System-on-Chip Design with Arm(R) Cortex(R)-M Processors, ARM Education Media, 2019

| B24EC2L06 | HDL LAB | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|---------|---|---|---|---|--------|----------------------|
|           |         | 0 | 0 | 3 | 2 | 2      | 2024                 |

**Preamble**

This lab course focuses on designing, simulating, and implementing digital systems using Verilog, emphasizing combinational and sequential circuits, FPGA interfacing, and practical real-world applications.

**Prerequisite**

B24EC1T03 : LOGIC CIRCUIT DESIGN

B24EC2L03 : LOGIC CIRCUIT DESIGN LAB

**Course Outcomes**

After the completion of the course the student will be able to

|             |                                                                                                                                                                                     |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Develop and simulate Verilog models for combinational and sequential circuits, including decoders, encoders, multiplexers, and flip-flops, to validate their functionality. [Apply] |
| <b>CO 2</b> | Design and implement a 32-bit Arithmetic Logic Unit (ALU) with multiple functionalities, and validate its behavior using comprehensive testbench scenarios. [Apply]                 |
| <b>CO 3</b> | Design clock divider circuits and implement FPGA-based control of DC and stepper motors, effectively managing speed and direction using Verilog. [Apply]                            |
| <b>CO 4</b> | Interface DACs with FPGA to generate waveforms like sine waves and design FSM-based control systems, such as an elevator, for real-world applications. [Apply]                      |
| <b>CO 5</b> | Develop Verilog modules for analog-to-digital conversion and display sensor outputs on various interfaces like LEDs, 7-segment displays, or LCDs. [Apply]                           |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| <b>CO 1</b> | 3   | 3   | 3   | 2   | 3   |     |     | 3   | 1   |      | 3    |
| <b>CO 2</b> | 3   | 3   | 1   | 2   | 3   |     |     | 3   |     |      | 1    |
| <b>CO 3</b> | 3   | 3   | 1   | 1   | 3   |     |     |     |     |      | 1    |
| <b>CO 4</b> | 3   | 3   | 1   | 1   | 3   |     |     |     |     |      | 1    |
| <b>CO 5</b> | 3   | 3   | 2   | 2   | 3   |     |     | 3   | 1   |      | 1    |

## Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hour       |

## Continuous Internal Evaluation Pattern

|                       |          |
|-----------------------|----------|
| Attendance            | 10 marks |
| Continuous Assessment | 20 marks |
| Internal Test         | 20 marks |

## End semester Examination pattern

|                                |          |
|--------------------------------|----------|
| Preliminary Work               | 30 marks |
| Performance and Implementation | 20 marks |
| Result and Inference           | 30 marks |
| Viva                           | 20 marks |

## SYLLABUS

## LIST OF EXPERIMENTS

### PART-A: Simulation

|          |                                                                                                                                                                                                                                                                                                                                                                                                                         |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>1</b> | Write a Verilog program for the following combinational designs, along with a testbench to verify each design:<br><br>1. Realization of a 2-to-4 decoder using only NAND gates<br><br>2. 8-to-3 encoder with and without priority<br><br>3. 8-to-1 multiplexer using both case and if statements<br><br>4. 4-bit binary to Gray code converter using a 1-bit Gray to binary converter, and a 1-bit adder and subtractor |
| <b>2</b> | Model a full adder and create a testbench with suitable input patterns to verify its behavior.                                                                                                                                                                                                                                                                                                                          |

|   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|---|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3 | <ol style="list-style-type: none"> <li>1. Design a 32-bit ALU and validate its functionality by using appropriate test patterns. The ALU should support the following operations: addition, subtraction, increment and decrement of the accumulator by 1, complement, logical OR, and logical AND. Inputs: A[31:0], B[31:0], Enable, Opcode[2:0], and Output: Result[32:0].</li> <li>2. Create a testbench to verify the ALU's functionality for all possible input patterns.</li> <li>3. The enable signal will activate the required functions when enabled; when disabled, all outputs will be set to tri-state.</li> <li>4. The acknowledge signal will be set high after each operation is completed.</li> </ol> |
| 4 | Write Verilog code for SR, D, JK flip flops and verify the functionality.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 5 | Write Verilog code for 4-bit BCD synchronous counter.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

### PART-B: Interfacing

|   |                                                                                                                                                                                                                                                                                                                                                                                                                              |
|---|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Design a clock divider circuit in Verilog to generate clock frequencies of $f/2$ , $f/3$ , and $f/4$ from a given input clock. Implement the design on an FPGA and verify its functionality using an oscilloscope.                                                                                                                                                                                                           |
| 2 | Write Verilog code to interface a DC motor with an FPGA and control its speed and direction.                                                                                                                                                                                                                                                                                                                                 |
| 3 | <p>Interface a stepper motor with an FPGA and write Verilog code to control its rotation. Use external DIP switches for the following controls:</p> <ol style="list-style-type: none"> <li>1. Rotate the stepper motor by +N steps when Switch 1 is closed.</li> <li>2. Rotate the stepper motor by +N/2 steps when Switch 2 is closed.</li> <li>3. Rotate the stepper motor by -N steps when Switch 3 is closed.</li> </ol> |
| 4 | Interface a DAC to FPGA and write Verilog code to generate Sine wave of desired frequency.                                                                                                                                                                                                                                                                                                                                   |
| 5 | Write Verilog code using a finite state machine (FSM) to simulate the operation of an elevator.                                                                                                                                                                                                                                                                                                                              |
| 6 | Write Verilog code to convert the analog output from a sensor into digital form and display the result on an appropriate display, such as LEDs, a 7-segment display, or an LCD.                                                                                                                                                                                                                                              |

### Reference Books

1. Pong P. Chu, FPGA Prototyping by Verilog Examples, John Wiley & Sons, 2008
2. FPGA-Based System Design –Wayne Wolf, Prentice Hall.



| B24ECM41 | MICROCON-<br>TROLLERS<br>(Minor) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|----------|----------------------------------|---|---|---|---|--------|-------------------------|
|          |                                  | 3 | 1 | 0 | 5 | 4      | 2024                    |

### Preamble

This course offers a focused study on 8051-based microcontrollers, covering their architecture, instruction set, and practical applications in embedded systems development.

### Prerequisites

Nil

### Course Outcomes

After the completion of the course the student will be able to:

|             |                                                                                                                                                                                                                                                       |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Students will gain proficiency in 8051 microcontroller architecture, memory organization, and interfacing techniques while understanding the distinctions between microprocessors and embedded microcontrollers. [Understand]                         |
| <b>CO 2</b> | Students will master the 8051 instruction set, addressing modes, and assembly language programming, enabling them to develop efficient embedded applications. [Understand, Apply]                                                                     |
| <b>CO 3</b> | Students will develop skills in 8051 stack operations, subroutine programming, and I/O port interfacing through assembly language, enabling the design of practical embedded applications like LED control and data manipulation. [Understand, Apply] |
| <b>CO 4</b> | Students will acquire the ability to program 8051 timers, counters, and serial ports for tasks like pulse generation and serial data communication using both Assembly and C languages. [Understand, Apply]                                           |
| <b>CO 5</b> | Students will gain expertise in handling 8051 interrupts and interfacing applications, including ADC, LCD, and stepper motor control, through Assembly and C programming. [Understand, Apply]                                                         |

### Mapping of Course Outcomes With Program Outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 2    | 3    | 2    |      | 1    |      |      |      |       | 3     |
| <b>CO 2</b> | 3    | 2    | 3    | 2    |      | 1    |      |      |      |       | 3     |
| <b>CO 3</b> | 3    | 2    | 3    | 2    |      | 1    |      |      |      |       | 3     |
| <b>CO 4</b> | 3    | 2    | 3    | 2    |      | 1    |      |      |      |       | 3     |
| <b>CO 5</b> | 3    | 2    | 3    | 2    |      | 1    |      |      |      |       | 3     |



### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 30                    | 30                 | 30                                    |
| Apply            | 50                    | 50                 | 50                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**8051 Microcontroller:** Microprocessor Vs Microcontroller, Embedded Systems, Embedded Microcontrollers, 8051 Architecture- Registers, Pin diagram, I/O ports functions, Internal Memory organization. External Memory (ROM & RAM) interfacing.

### MODULE 2

**8051 Instruction Set:** Addressing Modes, Data Transfer instructions, Arithmetic instructions, Logical instructions, Branch instructions, Bit manipulation instructions. Simple Assembly language program examples to use these instructions.

### MODULE 3

**8051 Stack, I/O Port Interfacing and Programming:** 8051 Stack, I/O Port Interfacing and Programming: 8051 Stack, Stack and Subroutine instructions. Assembly language program examples on subroutine and involving loops - Delay subroutine, Factorial of an 8bit number, Block move without overlap, Addition of N 8bit numbers, Picking smallest/largest of N 8bit numbers. Interfacing simple switch and LED to I/O ports to switch on/off LED with respect to switch status.

### MODULE 4

**8051 Timers and Serial Port:** 8051 Timers and Counters – Operation and Assembly language programming to generate a pulse using Mode-1 and a square wave using Mode-2 on a port pin. 8051 Serial Communication- Basics of Serial Data Communication, RS-232 standard, 9 pin RS232 signals, Simple Serial Port programming in Assembly and C to transmit a message and to receive data serially.

### MODULE 5

**8051 Interrupts and Interfacing Applications:** 8051 Interrupts. 8051 Assembly language programming to generate an external interrupt using a switch, 8051 C programming to generate a square waveform on a port pin using a Timer interrupt. Interfacing 8051 to ADC-0804, LCD and Stepper motor and their 8051 Assembly language interfacing programming.

**Text Books**

1. The 8051 Microcontroller and Embedded Systems – using assembly and C, Muhammad Ali Mazidi and Janice Gillespie Mazidi and Rollin D. McKinlay; PHI, Pearson, 2006.
2. The 8051 Microcontroller, Kenneth J. Ayala, 3rd Edition, Thomson/Cengage Learning.



**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                               | <b>No of Lecture/Tutorial Hours</b> |
|-----------|----------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                                            | <b>10</b>                           |
| 1.1       | Microprocessor Vs Microcontroller, Embedded Systems.                                                                       | 2                                   |
| 1.2       | Embedded Microcontrollers.                                                                                                 | 1                                   |
| 1.3       | 8051 Architecture- Registers, Pin diagram.                                                                                 | 2                                   |
| 1.4       | I/O ports functions.                                                                                                       | 2                                   |
| 1.5       | Internal Memory organization. External Memory (ROM & RAM) interfacing..                                                    | 3                                   |
|           | <b>Module 2</b>                                                                                                            | <b>9</b>                            |
| 2.1       | Addressing Modes.                                                                                                          | 1                                   |
| 2.2       | Data Transfer instructions.                                                                                                | 2                                   |
| 2.3       | Arithmetic instructions, Logical instructions.                                                                             | 2                                   |
| 2.4       | Branch instructions, Bit manipulation instructions.                                                                        | 2                                   |
| 2.5       | Simple Assembly language program examples to use these instructions.                                                       | 2                                   |
|           | <b>Module 3</b>                                                                                                            | <b>10</b>                           |
| 3.1       | 8051 Stack, Stack and Subroutine instructions.                                                                             | 2                                   |
| 3.2       | Assembly language program examples on subroutine and involving loops - Delay subroutine, Factorial of an 8bit number.      | 4                                   |
| 3.3       | Block move without overlap, Addition of N 8bit numbers, Picking smallest/ largest of N 8bit numbers.                       | 2                                   |
| 3.4       | Interfacing simple switch and LED to I/O ports to switch on/off LED with respect to switch status.                         | 2                                   |
|           | <b>Module 4</b>                                                                                                            | <b>8</b>                            |
| 4.1       | 8051 Timers and Counters.                                                                                                  | 2                                   |
| 4.2       | Operation and Assembly language programming to generate a pulse using Mode-1 and a square wave using Mode-2 on a port pin. | 2                                   |
| 4.3       | 8051 Serial Communication, Basics of Serial Data Communication, RS-232 standard.                                           | 2                                   |
| 4.4       | 9 pin RS232 signals, Simple Serial Port programming in Assembly and C to transmit a message and to receive data serially.  | 2                                   |
|           | <b>Module 5</b>                                                                                                            | <b>8</b>                            |
| 5.1       | 8051 Interrupts.                                                                                                           | 2                                   |
| 5.2       | 8051 Assembly language programming to generate an external interrupt using a switch.                                       | 1                                   |
| 5.3       | 8051 C programming to generate a square waveform on a port pin using a Timer interrupt.                                    | 1                                   |

|     |                                                                                                               |                 |
|-----|---------------------------------------------------------------------------------------------------------------|-----------------|
| 5.4 | Interfacing 8051 to ADC-0804, LCD and Stepper motor and their 8051 Assembly language interfacing programming. | 4               |
|     | <b>Total Hours</b>                                                                                            | <b>45 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Compare and contrast microprocessors and microcontrollers. Discuss the role of embedded systems and how embedded microcontrollers like the 8051 differ from general-purpose microprocessors. Include an explanation of the 8051 microcontroller architecture, detailing its registers, pin diagram, and I/O port functions.
2. Explain the internal and external memory organization of the 8051 microcontroller. Provide an in-depth analysis of how internal ROM, RAM, and I/O ports function in the 8051. Additionally, describe the interfacing of external memory (ROM & RAM) with the 8051 microcontroller, including the necessary connections and considerations.

#### Course Outcome 2 (CO 2):

1. Discuss the different addressing modes in the 8051 microcontroller. Provide examples of data transfer instructions, arithmetic instructions, logical instructions, and branch instructions in 8051 assembly language. Write a simple assembly language program that demonstrates the use of these instructions.
2. Explain the bit manipulation instructions in the 8051 microcontroller. Illustrate their usage with examples and write an assembly language program that utilizes bit manipulation instructions to perform a specific task, such as toggling a bit or testing a bit in a register.

#### Course Outcome 3 (CO 3):

1. Write an assembly language program for the 8051 microcontroller that calculates the factorial of a given 8-bit number using a subroutine and a loop. The program should prompt the user to input a number, call a subroutine to calculate its factorial, and return the result. Ensure that the program handles the stack properly and can compute factorials for numbers between 0 and 255.

2. Write an assembly language program for the 8051 microcontroller that sums up N 8-bit numbers (where N is specified by the user) using loops and a subroutine. The program should store the sum in a memory location and display the result. Use a subroutine to handle the summation, and implement the loop to process each of the N numbers.

**Course Outcome 4 (CO 4):**

1. Write an assembly language (or C) program for the 8051 microcontroller to implement serial communication. The program should transmit a message (e.g., "HELLO") via the serial port using the RS-232 standard, and then receive a response (e.g., "ACKNOWLEDGED") through the same port.
2. Write an assembly language program for the 8051 microcontroller to generate a 1-second delay using Timer 0 in Mode-1 (16-bit timer mode). The program should: Configure Timer 0 in Mode-1. Calculate the appropriate values for the Timer 0 reload register to achieve a delay of 1 second. Implement the delay and output a signal on a port pin (e.g., P1.0) each time the delay completes. Use an infinite loop to continuously toggle the signal every second.

Hint: Assume the system clock frequency is 12 MHz.

**Course Outcome 5 (CO 5):**

1. Write an assembly language program for the 8051 microcontroller to interface and display a message on a 16x2 LCD. The program should:  
Initialize the LCD in 8-bit mode. Display the message "HELLO, 8051!" on the first line of the LCD. Use the second line to display the current message "LCD INTERFACE". Provide necessary delays between writing characters to the LCD to ensure proper display timing. Configure the control pins (RS, RW, and E) and data pins (D0-D7) for the interface.
2. Write an assembly language program for the 8051 microcontroller that handles external interrupts and uses an interrupt service routine (ISR) to toggle an LED connected to a port pin. The program should:  
Set up External Interrupt 0 (INT0) to trigger on a falling edge. Configure an LED on port P1.0. When an external interrupt is triggered (via a switch connected to INT0), the interrupt service routine should toggle the LED connected to P1.0. Ensure that the program returns to normal operation after handling the interrupt and continues to monitor for additional interrupts. Include a delay in the main program loop to debounce the switch and avoid false triggers.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FORTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2024**

**Course Code: B24ECM41**

**Course Name: Microcontrollers**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Explain the key differences between a microprocessor and a microcontroller.
2. How is external memory interfaced with the 8051 microcontroller?
3. What are bit-manipulation instructions in the 8051?
4. Write a simple assembly program to perform the addition of two 8-bit numbers using 8051 arithmetic instructions.
5. How does 8051 handle subroutine calls?
6. What is the stack in the 8051 microcontroller, and how is it used for storing data?
7. How are the 8051 Timers and Counters used to generate precise time delays?
8. List the 9 pins of the RS-232 connector and describe their functions.
9. Describe how Timer 0 can be configured to generate an interrupt periodically?
10. Explain the interfacing of a stepper motor with the 8051 microcontroller.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Draw and explain the pin diagram of the 8051 microcontroller. (7)  
b) Describe the functions of I/O ports and explain the internal memory organization in detail. (7)
12. Describe the architecture of the 8051 microcontroller. Explain the roles of its registers and how they contribute to its functionality. (14)

**Module II**

13. a) Classify the 8051 instruction set into data transfer, arithmetic, logical, branching, and bit manipulation instructions. Give two examples for each category. (7)  
b) Explain the difference between the instructions ADD A, R1 and ADDC A, R1. Write an assembly language example for each. (3)  
c) Differentiate between SJMP and LJMP instructions with an example for each. Discuss their use cases in program design. (4)
14. a) Write a program to perform bitwise AND and OR operations between two bytes stored at memory locations 30H and 31H. Store the results in 32H and 33H, respectively. Use appropriate logical instructions. (7)  
b) Explain the role of the NOP, CLR, and SWAP instructions in the 8051 instruction set with examples. (7)

**Module III**

15. a) Write an assembly language program to toggle an LED connected to Port 1, Pin 0 (P1.0) with a delay. Use a subroutine to generate the delay. (7)  
b) Write an assembly program to calculate the sum of the first 10 natural numbers using a loop. Store the result in the accumulator (ACC). Include a subroutine to clear the accumulator before adding. (7)
16. a) Write an assembly language program for the 8051 microcontroller to generate a square wave of 50% duty cycle on Port 2, Pin 3 (P2.3). Use a subroutine for the delay. (7)  
b) Write an 8051 assembly program to move a block of data from internal memory locations 20H-29H to 30H-39H using a loop. Include a subroutine to clear the destination memory block before copying. (7)

**Module IV**

17. a) Explain the difference between Timers and Counters in the 8051 microcontroller. How are they configured and used in embedded systems? (7)  
b) Describe Timer Mode 2 (8-bit auto-reload mode). Write an assembly program to generate a square wave of 1kHz on P2.3 using Timer 0 in Mode 2. (7)
18. a) Explain the role of UART in the 8051 microcontroller. What are the key registers involved in serial communication? (7)

- b) How is the baud rate for serial communication determined in the 8051? If Timer 1 is set in Mode 2, calculate the TH1 value required for a baud rate of 9600 with a 12 MHz crystal frequency. (7)

**Module V**

19. a) Explain the interrupt structure of the 8051 microcontroller. How many interrupt sources are available, and what are their priorities? (7)  
b) How does the 8051 handle nested interrupts? Provide an example program where Timer 0 interrupt has higher priority than INT0. (7)
20. a) Write the sequence of steps required to initialize a 16x2 LCD in 8-bit mode. Include the initialization commands. (7)  
b) Design a system using the 8051 to display the temperature value read from a sensor on an LCD. Assume the temperature data is available in the accumulator. (7)

| <b>B24ECM42</b> | <b>DIGITAL COMMUNICATION<br/>(Minor)</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF INTRODUCTION</b> |
|-----------------|------------------------------------------|----------|----------|----------|----------|---------------|-----------------------------|
|                 |                                          | 3        | 1        | 0        | 5        |               |                             |

**Preamble:**

Digital communication explores the principles and technologies that enable efficient and reliable transmission of information in digital form, forming the backbone of modern connectivity and innovation.

**Prerequisites:**

NIL

**Course Outcomes:**

After the completion of the course the student will be able to:

|             |                                                                                                                                                                            |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Develop a strong foundation in random processes (Cognitive Knowledge Level: Understand)                                                                                    |
| <b>CO 2</b> | To understand the Performance comparison various pulse modulation schemes (Cognitive Knowledge Level: Understand)                                                          |
| <b>CO 3</b> | To understand signal space representation of signal and to apply waveform coding techniques in digital transmission for zero ISI. (Cognitive Knowledge Level: Apply)       |
| <b>CO 4</b> | Analyze and design baseband transmission systems with minimal inter-symbol interference, incorporating concepts like Nyquist criteria (Cognitive Knowledge Level: Analyze) |
| <b>CO 5</b> | Design and analyze bandpass digital modulation schemes such as ASK, FSK, PSK, and QAM (Cognitive Knowledge Level: Apply)                                                   |

**Mapping of Course Outcomes With Program Outcomes**

|             | <b>PO 1</b> | <b>PO 2</b> | <b>PO 3</b> | <b>PO 4</b> | <b>PO 5</b> | <b>PO 6</b> | <b>PO 7</b> | <b>PO 8</b> | <b>PO 9</b> | <b>PO 10</b> | <b>PO 11</b> |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|
| <b>CO 1</b> | 2           | 1           | 2           | 2           | 1           | 2           |             |             |             |              | 1            |
| <b>CO 2</b> | 1           | 2           | 2           | 1           | 2           | 2           |             |             |             |              | 1            |
| <b>CO 3</b> | 3           | 2           | 3           | 1           | 2           | 2           |             |             |             |              | 2            |
| <b>CO 4</b> | 3           | 2           | 3           | 2           | 3           | 3           | 1           | 1           |             |              | 2            |
| <b>CO 5</b> | 2           | 1           | 3           | 1           | 3           | 2           | 1           |             |             |              | 2            |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                     | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|---------------------|---------------------------------------|
|                  | Test 1<br>(% Marks)   | Test 2<br>(% Marks) |                                       |
| Remember         | 30                    | 30                  | 30                                    |
| Understand       | 50                    | 50                  | 50                                    |
| Apply            | 20                    | 20                  | 20                                    |
| Analyse          |                       |                     |                                       |
| Evaluate         |                       |                     |                                       |
| Create           |                       |                     |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Quiz/Course project         | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

#### Random Signal Theory

Stationarity random process , WSS random process,ergodicity, mean, auto correlation, co-variance, random process transmission through linear filters, power spectral density, cross correlation functions, cross spectral densities, Gaussian process, Discrete Time Random Process, White Process

## **MODULE 2**

### **Pulse Modulation schemes**

Sampling and pulse modulation: Sampling theorem, Ideal sampling and reconstruction, practical sampling and Aliasing, PAM, PWM. Quantization, Quantization Noise, Companding, PCM generation and reconstruction, DPCM transmitter and receiver, Delta modulation, drawbacks of delta modulation.

## **MODULE 3**

### **Signal Space representation and transmission**

Signal Space Concepts, Gram- Schmidt Orthogonalization Procedure . Baseband transmission through AWGN channel.

**Baseband shaping for Data Transmission :** Binary signaling format, inter symbol interference, mathematical model of ISI. Nyquist criterion for zero ISI. Signal modeling for ISI, ideal and practical solutions raised cosine spectrum and square-root raised cosine pulse. Eye pattern

## **MODULE 4**

**Transmission Over AWGN Channel:** Conversion of continuous AWGN channel into a vector channel, likelihood function, maximum likelihood decoding, maximum likelihood receiver, Matched filter and its properties, correlation receivers, probability of error in receiver.

## **MODULE 5**

Digital CW Modulation: ASK, BFSK, BPSK (need introduction only). BPSK transmitter and receiver. Base band QPSK transmitter and receiver with Signal constellations. Probability of error of BPSK and BFSK, Quadrature amplitude modulation and signal constellations.

### **Text Books**

1. Simon Haykin , Introduction To Analog And Digital Communications, Wiley India Edition.
2. Simon Haykin , Digital Communications, Wiley India Edition.
3. John G. Proakis, Masoud Salehi, Digital Communication, McGraw Hill Education Edition, 2014.

### **Reference Books**

1. Simon Haykin, Communication Systems, 4/e Wiley India, 2012



2. Carlson, Crilly, Rutledge, "Communication Systems" 4th Edition, McGraw Hill
3. Sklar: Digital Communication, 2E, Pearson Education.
4. Herbert Taub, Schilling Donald L., "Principles of Communication Systems, 3rd e/d, Tata Mc Graw Hill, 2007.

## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                                                        | No of Lecture/Tutorial Hours |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1 (Random Signal Theory)</b>                                                                                                                                                       | 10 hours                     |
| 1.1 | Random process: stationarity random process, WSS random process, ergodicity.                                                                                                                 | 1 hour                       |
| 1.2 | mean, auto correlation.                                                                                                                                                                      | 2 hours                      |
| 1.3 | cross correlation, covariance, random process transmission through linear filters.                                                                                                           | 3 hours                      |
| 1.4 | power spectral density, cross correlation functions, cross spectral densities.                                                                                                               | 2 hours                      |
| 1.5 | Gaussian process, Discrete Time Random Process, White Process.                                                                                                                               | 2 hours                      |
|     | <b>Module 2 (Pulse Modulation schemes)</b>                                                                                                                                                   | 8 hours                      |
| 2.1 | Pulse Modulation Techniques: Sampling and pulse modulation: Sampling theorem, Ideal sampling and reconstruction, practical sampling and Aliasing, PCM generation and reconstruction .        | 3 hours                      |
| 2.2 | PAM, PWM, Quantizing, Quantization error, Companding.                                                                                                                                        | 3 hours                      |
| 2.3 | DPCM transmitter and receiver, Delta Modulation, Drawbacks of delta modulation, problems based on slope overload distortion.                                                                 | 2 hour                       |
|     | <b>Module 3 (Signal Space representation and transmission)</b>                                                                                                                               | 10 hours                     |
| 3.1 | Signal Space Representation of Waveforms: Signal Space Concepts, Gram- Schmidt Orthogonalization Procedure with problem                                                                      | 3 hours                      |
| 3.2 | Detection and Estimation: Baseband transmission through AWGN channel. Baseband shaping for Data Transmission: Binary signaling format, inter symbol interference, mathematical model of ISI. | 4 hours                      |
| 3.3 | Nyquist criterion for zero ISI. ideal and practical solution<br>Signal modeling for ISI, raised cosine spectrum and                                                                          | 3 hours                      |
| 3.4 | square-root raised cosine pulse and eye pattern                                                                                                                                              | 1 hour                       |
|     | <b>Module 4 (Detection and estimation)</b>                                                                                                                                                   | 9 hours                      |

|     |                                                                                                    |          |
|-----|----------------------------------------------------------------------------------------------------|----------|
| 4.1 | Transmission Over AWGN Channel: Conversion of the continuous AWGN channel into a vector channel, . | 2 hours  |
| 4.2 | Likelihood function, Maximum Likelihood Decoding, Maximum likelihood receiver                      | 3 hours  |
| 4.3 | Matched filter and correlation receivers and probability of error in optimum receiver.             | 4 hours  |
|     | <b>Module 5 (Advanced Materials and Devices for Engineering Applications)</b>                      | 8 hours  |
| 5.1 | Digital modulation schemes. Digital CW Modulation: ASK, BFSK, BPSK .                               | 2 hours  |
| 5.2 | BPSK signal representation and constellation, transmitter and receiver.                            | 2 hours  |
| 5.3 | Base band QPSK system and Signal constellations, transmitter and receiver.                         | 2 hours  |
| 5.4 | Probability of error of BPSK and BFSK.                                                             | 1 hour   |
| 5.5 | Quadrature amplitude modulation and signal constellation.                                          | 1 hour   |
|     | <b>Total Hours</b>                                                                                 | 45 Hours |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Define stationarity and differentiate between strict-sense stationarity (SSS) and wide-sense stationarity (WSS) with examples..
2. Describe the mean, autocorrelation, and cross-correlation functions for a random process and their physical interpretations.
3. Prove that the output of a stationary random process passing through a linear filter remains stationary.
4. What are the key properties of a Gaussian random process, and why is it widely used in signal processing?

#### Course Outcome 2 (CO 2):

1. State and explain the Sampling Theorem. Why is it important in digital communication?
2. Describe the steps involved in the generation and reconstruction of PCM signals.
3. Analyze the drawbacks of Delta Modulation, particularly slope overload distortion, and propose solutions to overcome these issues.

4. Analyze the trade-offs between PCM, DPCM, and Delta Modulation for bandwidth and signal-to-noise ratio.

**Course Outcome 3 (CO 3):**

1. Define the Signal Space Concept and explain its significance in communication systems.
2. Illustrate the Gram-Schmidt orthogonalization procedure to represent a given set of waveforms using orthogonal basis.
3. Define Inter-Symbol Interference (ISI) and describe its mathematical model.
4. State and explain the Nyquist Criterion for Zero ISI. Compare and contrast the raised cosine spectrum and the square-root raised cosine spectrum.
5. Elaborate the significance of eye pattern

**Course Outcome 4 (CO 4):**

1. Define the likelihood function and its role in detection and decoding.
2. Explain Maximum Likelihood (ML) Decoding .
3. Analyze the performance difference between a correlation receiver and a matched filter receiver in detecting signals transmitted over an AWGN channel?

**Course Outcome 5 (CO 5):**

1. Define different digital modulation schemes and explain their basic principles.
2. Describe the operation of a BPSK & QPSK transmitter and receiver with a block diagram.
3. Analyze the probability of error of BFSK and compare it with BPSK.
4. Explain the relationship between the number of constellation points in a QAM system and its data rate.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 2**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FOURTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2025**

**Course Code: B24ECM42**

**Course Name: DIGITAL COMMUNICATION**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks.**

1. Define the Power spectral Density (PSD) of a stationary random process  $X(t)$ .
2. A continuous random variable  $X$  is uniformly distributed in the interval  $[0,8]$ . Find its PDF?
3. What is Companding, and why is it used in communication systems?
4. What is slope overload distortion in Delta Modulation? How can it be mitigated?
5. Why signal-to-noise ratio (SNR) is important in an AWGN channel?
6. Explain the significance of roll-off factor in raised cosine pulse.
7. Describe the key differences between a matched filter and a correlation receiver?
8. What is the likelihood function in the context of AWGN channels?
9. What are the advantages of QPSK over BPSK?
10. Draw the constellation plot for the BPSK system and explain.

**PART B**

**Answer any one question from each module. Each question carries 14 marks.**

1. (a) A random process  $A \cos(\omega t + \phi)$  is defined, where  $A, \omega$  are constants, and  $\phi$  is uniformly distributed over  $[0, 2\pi]$ . (a) Is the process stationary in the strict sense? 8  
(b) Is it wide-sense stationary?
- (b) Discuss how a random process is affected when passed through a linear time-invariant (LTI) filter. Derive the expression for the output autocorrelation function. 6

**OR**

2. (a) A white noise process  $X(t)$  has a constant power spectral density (PSD)

$$S_X(f) = \frac{N_0}{2}.$$

(i) Derive the autocorrelation function  $R_X(\tau)$ . (ii) Calculate the output PSD if  $X(t)$  is passed through a low-pass filter with

$$H(f) = \frac{1}{1 + jf}.$$

- . 9
- (b) What is a white noise process? Discuss its autocorrelation function and power spectral density. 5
3. (a) Explain the transmitter and receiver structure of Differential Pulse Code Modulation. Discuss its advantages over standard PCM. 8  
(b) A 4 kHz message signal is sampled at 8 kHz, quantized into 8 levels, and encoded using PCM. Determine: (a) The bit rate of the PCM signal. (b) The bandwidth required to transmit this PCM signal. 6

**OR**

4. (a) A message signal  $x(t) = \sin(2\pi \cdot 100t)$  is to be encoded using delta modulation. The sampling rate is 10 KHz, and the step size is  $\Delta = 0.1V$ . (a) Determine if slope overload distortion occurs. (b) Calculate the maximum permissible step size to avoid slope overload. 9  
(b) Explain the working of Delta Modulation and discuss its drawbacks. 5
5. (a) State and explain the Nyquist criterion for zero inter symbol interference. 8  
(b) Explain the significance of the raised cosine spectrum in minimizing inter-symbol interference. 6

**OR**

6. (a) Explain the Gram-Schmidt orthogonalization procedure with an example. 10  
(b) Describe how an eye pattern can be used to assess the performance of a digital communication system. 4
7. (a) What is a matched filter receiver? Derive the output of the matched filter for a signal transmitted over an AWGN channel. 9

- (b) Explain the properties of Matched filter? 5

**OR**

8. (a) What is Maximum Likelihood (ML) Decoding? Discuss its significance in minimizing the probability of error in a communication system. 7  
(b) How is a continuous AWGN channel converted into a vector channel? 7
9. (a) Draw and explain the signal constellation diagram for QPSK modulation. Explain its transmitter and receiver. 10  
(b) What is meant by quadrature amplitude modulation? Plot different constellation for the same. 4

**OR**

10. (a) Derive the expression of probability of error for BPSK 14



| B24ECM43 | INTRODUCTION<br>TO DIGITAL<br>SIGNAL<br>PROCESSING<br>(Minor) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|----------|---------------------------------------------------------------|---|---|---|---|--------|-------------------------|
|          |                                                               | 3 | 1 | 0 | 5 |        |                         |

**Preamble:** This course aims to give an introduction to digital signal processing

**Prerequisite:** B24ECM33 : Introduction to Signals and Systems

**Course Outcomes:** After the completion of the course the student will be able to

|      |                                                                                                          |
|------|----------------------------------------------------------------------------------------------------------|
| CO 1 | Explain how digital signals are obtained from continuous time signals.                                   |
| CO 2 | Solve basic problems involving DFT using its properties and FFT algorithms                               |
| CO 3 | Design and realize FIR and IIR filters for a given specification                                         |
| CO 4 | Understand finite precision representation of numbers in a digital system and finite word length effects |
| CO 5 | Understand the multiprocessor architecture of the DSP processors.                                        |

Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 1    |      |      |      |      |      |      |      |       |       |
| CO 2 | 3    | 3    | 2    | 2    | 3    |      |      | 3    |      |       | 1     |
| CO 3 | 3    | 2    | 3    | 3    | 3    |      |      | 3    |      |       |       |
| CO 4 | 3    | 1    |      |      |      |      |      |      |      |       |       |
| CO 5 | 3    | 1    |      |      | 1    |      |      |      |      |       |       |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |        | End Semester Examination |
|------------------|-----------------------|--------|--------------------------|
|                  | Test 1                | Test 2 |                          |
| Remember         | 30                    | 30     | 30                       |
| Understand       | 30                    | 30     | 30                       |
| Apply            | 40                    | 40     | 40                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Quiz/Course project         | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## **SYLLABUS**

### **MODULE 1**

Discrete-time and digital signals. Basic elements of digital processing system- ADC, DAC and Nyquist rate. Frequency aliasing due to sampling. Need for anti-aliasing filters. Discrete-Time Fourier Transforms– Properties(proof not required). Computation of spectrum.

### **MODULE 2**

Discrete Fourier transform - DFT as a linear transformation, Properties(proof not required) - circular convolution. Filtering of long data sequences - FFT-Radix-2 DIT and DIF algorithms. Computational complexity of DFT and FFT .

### **MODULE 3**

Digital FIR Filter: Linear phase FIR filter, Design of FIR filter using windowing method (Rectangular, Hamming, Hanning), Direct form and cascade realization of FIR filters. Digital IIR Filters.IIR filter design by impulse invariance and bilinear transformation, Frequency transformations in the analog and digital domain. Design of analog Butterworth filter. Realization of IIR filter: Direct form.

### **MODULE 4**

Fixed point arithmetic, Floating point arithmetic, Truncation and Rounding, Quantization error in ADC, Overflow error, Product round-off error, Scaling, Limit cycle oscillation.

### **MODULE 5**

General and special purpose hardware for DSP: Computer architectures for DSP – Harvard, pipelining, MAC, special instruction, replication, on-chip cache. General-purpose digital signal processors (TMS 320 family) - Implementation of digital filtering on DSP processor. Special purpose DSP hardware

### **Text Books**

1. Proakis, J.G. & Manolakis, D.G., “Digital Signal Processing: Principles, Algorithms,& Applications”, 3/e Prentice Hall of India, 1996
2. Ifeachor, E.C., & Jervis, B.W., “Digital Signal Processing: A Practical Approach”,2/e, Pearson Education Asia, 2002.
3. Chen, C.T., “Digital Signal Processing: Spectral Computation & Filter Design”, Oxford Univ. Press, 2001.
4. Mitra, S.K., “Digital Signal Processing: A Computer-Based Approach”, McGraw Hill, NY, 1998
5. Monson H Hayes, Schaums outline: Digital Signal Processing

## COURSE CONTENTS AND LECTURE SCHEDULE

| No       | Topic                                                                                                                                                                                             | No of Lecture/Tutorial Hours |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
| <b>1</b> | <b>Module 1</b>                                                                                                                                                                                   | <b>8</b>                     |
| 1.1      | Overview of signals. Frequency elements of DSP systems.                                                                                                                                           | 2                            |
| 1.2      | Conversion of analog signals to digital signals, Sampling theorem, reconstruction ADC and DAC, spectra and anti-aliasing filter                                                                   | 3                            |
| 1.3      | DTFT properties(proof not required)., spectrum                                                                                                                                                    | 3                            |
| <b>2</b> | <b>Module 2</b>                                                                                                                                                                                   | <b>9</b>                     |
| 2.1      | DFT from DTFT, DFT as a linear transformation (proof not required). W matrix. Properties of DFT, Computational challenges.                                                                        | 3                            |
| 2.2      | FFT for computational advantage, Radix -2 DIT and DIF algorithm, in place computation. Bit reversal permutation. complexity                                                                       | 4                            |
| 2.3      | Filtering of long sequences                                                                                                                                                                       | 2                            |
| <b>3</b> | <b>Module 3</b>                                                                                                                                                                                   | <b>12</b>                    |
| 3.1      | Digital FIR Filter: Linear phase FIR filter, Design of FIR filter using windowing method (Rectangular, Hamming, Hanning) Direct form and cascade realization of FIR filters. Digital IIR Filters. | 5                            |
| 3.2      | IIR filter design by impulse invariance and bilinear transformation, Frequency transformations in the analog and digital domain.                                                                  | 3                            |
| 3.3      | Design of analog Butterworth filter. Realization of IIR filter: Direct form.                                                                                                                      | 4                            |
| <b>4</b> | <b>Module 4</b>                                                                                                                                                                                   | <b>7</b>                     |
| 4.1      | Number representation Truncation - Rounding - Quantization error in ADC - Overflow error- product round off error - Scaling - Limit cycle oscillation.                                            | 2                            |
| 4.2      | Truncation-Rounding - Quantization error in ADC - Overflow error - product round-off error - Scaling - Limit cycle oscillation.                                                                   | 5                            |
| <b>5</b> | <b>Module 5</b>                                                                                                                                                                                   | <b>9</b>                     |
| 5.1      | Von Neumann and Harvard architecture, Comparison                                                                                                                                                  | 2                            |
| 5.2      | Data paths of fixed and floating point DSP processors. Functions of various blocks Architecture of a typical DSP processor                                                                        | 5                            |
| 5.3      | Implementation of systems on DSP chip                                                                                                                                                             | 2                            |
|          | <b>Total Hours</b>                                                                                                                                                                                | <b>45</b>                    |

## Simulation Assignments

The following simulation assignments can be done with Python/MATLAB/SCILAB/OC-TAVE

1. Generate the following discrete signals
  - Impulse signal
  - Pulse signal and
  - Triangular signal
2. Write a function to compute the DFT of a discrete energy signal. Test this function on a few signals and plot their magnitude and phase spectra.
3.
  - Compute the linear convolution between the sequences  $x = [1, 3, 5, 3]$  with  $h = [2, 3, 5, 6]$ . Observe the stem plot of both signals and the convolution.
  - Now let  $h = [1, 2, 1]$  and  $x = [2, 3, 5, 6, 7]$ . Compute the convolution between  $h$  and  $x$ .
  - Flip the signal  $x$  by  $180^\circ$  so that it becomes  $[7, 6, 5, 3, 2]$ . Convolve it with  $h$ . Compare the result with the previous result.
  - Repeat the above two steps with  $h = [1, 2, 3, 2, 1]$  and  $h = [1, 2, 3, 4, 5, 4, 3, 2, 1]$
  - Give your inference.
4.
  - Compute the DFT matrix for  $N = 8, 16, 64, 1024$  and  $4098$
  - Plot the first 10 rows in each case and appreciate these basis functions
  - Plot the real part of these matrices as images and appreciate the periodicities and half periodicities in the pattern
  - Normalize each matrix by dividing by  $\sqrt{N}$ . Compute the eigenvalues of every normalized matrix and observe that all eigenvalues belong to the set  $\{1, j, -j, -1\}$ .
5. Realize a continuous time LTI system with system response

$$H(s) = \frac{5(s+1)}{(s+2)(s+3)}$$

One may use *scipy.signal.lti* package in Python.

- Make it into a discrete system (possibly with *scipy.signal.cont2discrete*)
  - Observe the step response in both cases and compare.
6.
    - Download a vibration signal in *.wav* format.
    - Load this signal into an array. One may use the *scipy.io.wavfile* module in Python.
    - Understand the sampling rate of this signal.
    - Plot and observe the vibration signal waveform.
    - Compute the absolute squared value of the FFT of the vibration signal.
    - Plot it and observe the spectral components in the discrete frequency domain.
    - Multiply prominent discrete frequencies by the sampling rate and observe and appreciate the major frequency components in *Hz*.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FOURTH SEMESTER B TECH DEGREE (MINOR) EXAMINATION,  
DECEMBER 2024**

**Course Code: B24ECM43**

**INTRODUCTION TO DIGITAL SIGNAL PROCESSING**

Max. Marks: 100

Duration: 3 hours

**PART A**

**(Answer all questions. Each question carries 3 marks.)**

1. Define frequency of a discrete signal and identify its range.
2. State Nyquist sampling theorem for low pass signals and the formula for signal reconstruction.
3. Explain why DFT operation is a linear transformation.
4. Explain how it reduces the computational complexity of DFT.
5. Write the expression for the Hamming window and plot it.
6. Give the expression for bilinear transformation and explain the term frequency warping.
7. Explain the quantization error in ADCs.
8. Explain the 1s and 2s complement representation of numbers in DSP processor.
9. Compare floating point and fixed point data paths in a DSP processor.
10. Explain the function of a barrel shifter in a DSP processor.

**PART B**

**(Answer any one question from each module. Each question carries 14 marks)**



### MODULE I

11. a. Explain how analog signals are converted to digital signals. (10 marks)  
b. What digital frequencies are obtained when a 1 kHz signal is sampled by 4kHz and 8 kHz impulse trains? (4marks)

OR

12. a. Give the expression for DTFT. Compute the DTFT of the signal  $x[n] = [1, -1, 1, -1]$ . (8 marks)  
b. Explain how sampling affects the spectrum of the signal and the need for an antialiasing filter. (6 marks)

### MODULE II

13. a. Give the radix-2 decimation in time algorithm for 8-point FFT computation. (10 Marks)  
b. How is in-place computation applied in FFT algorithms? (4 Marks)

OR

14. a. Find the DFT of the sequence  $x(n) = \{1, 2, 3, 4, 4, 3, 2, 1\}$  using radix-2 DIF algorithm (10 marks)  
b. How is bit reverse addressing used in FFT computations? (4 marks)

### MODULE III

15. a. Write the difference equation representation of the IIR filter and explain how its impulse response is infinite in duration (7 marks)  
b. Convert the analog filter  $H(s)$  into digital filter using impulse invariance method. (7 marks)

$$H(s) = \frac{1}{(s+1)(s+2)}$$

OR

16. a. Implement the FIR filter  $h[n] = [1, 2, 4, 6, 4, 2, 1]$  with minimum multipliers in direct form (6 marks)  
b. Design an IIR Butterworth filter for passband frequency 5 kHz and stopband frequency 10 kHz. The stop band and pass band attenuations are 0.1 respectively. (8 marks).

### MODULE IV

17. a. Explain the limit cycle oscillations in IIR filters (6 marks)  
b. Derive the quantization noise power in an ADC (8 marks)

OR

18. a. Find the output noise variance of a first-order system with transfer function  $H(z)$  that is driven by a zero mean white Gaussian noise of variance  $\sigma_N^2$ , where  $H(z)$  is given by (8 marks)

$$H(z) = \frac{1}{1 - \alpha z^{-1}}$$

- b. Explain the fixed and floating point arithmetic used in DSP processors. (6 marks)

**MODULE V**

19. Draw and explain the functional blocks in a floating point DSP processor. (14 marks)

OR

20. a. Compare Von Neumann architecture with Harvard architecture (7marks)  
b. Explain the significance and operation of the MAC unit in a DSP processor (7 marks)

| B24ECH41 | NANO<br>ELECTRONICS<br>(Honours) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|----------|----------------------------------|---|---|---|---|--------|-------------------------|
|          |                                  | 3 | 1 | 0 | 5 | 4      | 2024                    |

**Preamble**

This course aims to understand the physics behind mesoscopic systems and working of nanoelectronic devices.

**Prerequisites**

B24PH1T01A : Engineering Physics

B24EC2T04 : Solid State Devices.

**Course Outcomes**

After the completion of the course the student will be able to:

|             |                                                                                                                                     |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Explain Quantum mechanical effects of low dimensional semiconductors and solve numericals to find nanomaterial [Remember].          |
| <b>CO 2</b> | Understand the fabrication process of nanoparticles and nanolayers. [Understand]                                                    |
| <b>CO 3</b> | Explain the different techniques for characterizing nano-layers and particles.[Understand]                                          |
| <b>CO 4</b> | Understand the different transport mechanisms in nano structures.[Remember, Understand]                                             |
| <b>CO 5</b> | Illustrate the operating principle of nanoscale electronic devices like SET, Resonant tunneling devices, Quantum lasers etc.[Apply] |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 3    | 2    | 1    |      |      |      |      |      |       | 2     |
| <b>CO 2</b> | 3    | 2    | 1    | 1    |      |      |      |      |      |       | 2     |
| <b>CO 3</b> | 2    | 2    | 1    | 2    |      |      |      |      |      |       | 2     |
| <b>CO 4</b> | 3    | 2    | 1    | 1    |      |      |      |      |      |       | 2     |
| <b>CO 5</b> | 3    | 3    | 2    | 1    |      |      |      |      |      |       | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 40                    | 40              | 40                                 |
| Understand       | 40                    | 40              | 40                                 |
| Apply            | 20                    | 20              | 20                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

### Course Level Assessment Questions

#### Course Outcome 1 (CO1):

1. Derive the expression for density of states in a 1D nanomaterial.
2. Compare and contrast triangular, square and parabolic quantum wells.

3. Solve numerical problems to find whether the given material is a nanometric one.

**Course Outcome 2 (CO2) :**

1. Explain Sol-Gel process for synthesis of nanoparticles.
2. Explain the different steps involved in CVD process for fabricating nanolayers.
3. DC sputtering cannot be used for the coating of non- conducting materials. Justify.

**Course Outcome 3 (CO3):**

1. Illustrate the working principle of an AFM.
2. Explain the different emission and interactions between electron beam and the specimen.
3. Explain the principle of operation of an XRD.

**Course Outcome 4 (CO4):**

1. Explain Kronig Penney model of a super lattice.
2. Explain modulation doping with an example.
3. Explain the different scattering events encountered by a carrier during parallel transport under the influence of electric field.

**Course Outcome 5 (CO5):**

1. Explain Coulomb blockade effect. Illustrate the working of a single electron transistor.
2. Draw the schematic representation of the conduction band of a resonant tunnel diode for (a) no voltage applied (b) increasing applied voltages. Explain its I-V characteristics.
3. MODFETS are high electron mobility transistors. Justify.

## **SYLLABUS**

### **MODULE I**

Introduction to nanotechnology, characteristic lengths in mesoscopic systems, Quantum mechanical coherence Classification of Nano structures, Low dimensional structures Quantum wells, wires and dots, Density of states and dimensionality. Basic properties of two dimensional semiconductor nanostructures, square quantum wells of finite depth, parabolic and triangular quantum wells, Quantum wires and quantum dots, carbon nanotubes.

### **MODULE II**

Introduction to methods of fabrication of nano-layers, different approaches, physical vapour deposition, chemical vapour deposition. Molecular Beam Epitaxy, Ion Implantation, Formation of Silicon Dioxide- dry and wet oxidation methods. Fabrication of nano particle-grinding with iron balls, laser ablation, reduction methods, sol gel, self assembly, precipitation of quantum dots.

### **MODULE III**

Introduction to characterization of nanostructures, tools used for of nano materials characterization, microscope-optical, electron, and electron microscope. Principle of operation of Scanning Tunnelling Microscope, Atomic Force Microscope, Scanning Electron microscope, Specimen interaction. Transmission Electron Microscope. X-Ray Diffraction analysis, PL and UV Spectroscopy, Particle size analyser.

### **MODULE IV**

Two dimensional electronic system, two dimensional behaviour, MOSFET structures, Heterojunctions. Quantum wells, modulation doped quantum wells, The concept of super lattices Kronig - Penney model of super lattice.

### **MODULE V**

Nanoelectronic devices - MODFETS, Single Electron Transistor, CNT transistors – Properties of graphene Resonant tunnel effect, RTD, RTT, Hot electron transistors. Quantum well laser, quantum dot LED, quantum dot laser. Quantum well optical modulator, quantum well sub band photo detectors, principle of NEMS.



**Text Books**

1. J.M. Martinez-Duart, R.J. Martin Palma, F. Agulle Rueda Nanotechnology for Microelectronics and optoelectronics , Elsevier, 2006
2. W.R. Fahrner, Nanotechnology and Nanoelectronics, Springer, 2005.

**Reference Books**

1. Chattopadhyay, Banerjee, Introduction to Nanoscience & Technology, PHI 2012
2. Poole, Introduction to Nanotechnology, John Wiley 2006.
3. George W. Hanson, Fundamentals of Nanoelectronics, Pearson Education, 2009.
4. K. Goser, P. Glosekotter, J. Dienstuhl, Nanoelectronics and nanosystems, Springer 2004.
5. Supriyo Dutta, Quantum Transport- Atom to transistor, Cambridge, 2013.

## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                 | No of Lecture/Tutorial Hours |
|-----|---------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                       | <b>10</b>                    |
| 1.1 | Introduction to nanotechnology, characteristic lengths in mesoscopic systems, Quantum mechanical coherence .                          | 2                            |
| 1.2 | Classification of Nano structures, Low dimensional structures Quantum wells, wires and dots.                                          | 2                            |
| 1.3 | Density of states and dimensionality.                                                                                                 | 1                            |
| 1.4 | Basic properties of two dimensional semiconductor nanostructures.                                                                     | 1                            |
| 1.5 | Square quantum wells of finite depth, parabolic and triangular quantum wells.                                                         | 1                            |
| 1.6 | Quantum wires and quantum dots.                                                                                                       | 1                            |
| 1.7 | carbon nanotubes.                                                                                                                     | 1                            |
| 1.8 | TUTORIAL.                                                                                                                             | 1                            |
|     | <b>Module 2</b>                                                                                                                       | <b>9</b>                     |
| 2.1 | Introduction to methods of fabrication of nano-layers, different approaches, physical vapour deposition.                              | 2                            |
| 2.2 | Chemical vapour deposition.                                                                                                           | 1                            |
| 2.3 | Molecular Beam Epitaxy, Ion Implantation.                                                                                             | 1                            |
| 2.4 | Formation of Silicon Dioxide- dry and wet oxidation methods.                                                                          | 1                            |
| 2.5 | Fabrication of nano particle- grinding with iron balls, laser ablation, reduction methods                                             | 2                            |
| 2.6 | sol gel, self assembly, precipitation of quantum dots.                                                                                | 2                            |
|     | <b>Module 3</b>                                                                                                                       | <b>12</b>                    |
| 3.1 | Introduction to characterization of nanostructures                                                                                    | 2                            |
| 3.2 | tools used for of nano materials characterization, microscope-optical, electron, and electron microscope.                             | 2                            |
| 3.3 | Principle of operation of Scanning Tunnelling Microscope, Atomic Force Microscope, Scanning Electron microscope, Specimen interaction | 3                            |
| 3.4 | Transmission Electron Microscope. X-Ray Diffraction analysis                                                                          | 2                            |
| 3.5 | PL and UV Spectroscopy, Particle size analyser.                                                                                       | 2                            |
| 3.6 | TUTORIAL                                                                                                                              | 1                            |
|     | <b>Module 4</b>                                                                                                                       | <b>9</b>                     |
| 4.1 | Two dimensional electronic system, two dimensional behaviour.                                                                         | 2                            |
| 4.2 | MOSFET structures, Heterojunctions.                                                                                                   | 2                            |
| 4.3 | Quantum wells, modulation doped quantum wells                                                                                         | 2                            |
| 4.4 | The concept of super lattices Kronig - Penney model of super lattice.                                                                 | 2                            |

|     |                                                                        |                 |
|-----|------------------------------------------------------------------------|-----------------|
| 4.5 | TUTORIAL                                                               | 1               |
|     | <b>Module 5</b>                                                        | <b>8</b>        |
| 5.1 | Nanoelectronic devices - MODFETS.                                      | 1               |
| 5.2 | Single Electron Transistor, CNT transistors                            | 1               |
| 5.3 | Properties of graphene, Resonant tunnel effect                         | 1               |
| 5.4 | RTD, RTT, Hot electron transistors.                                    | 1               |
| 5.5 | Quantum well laser, quantum dot LED, quantum dot laser.                | 1               |
| 5.6 | Quantum well optical modulator, quantum well sub band photo detectors. | 2               |
| 5.7 | Principle of NEMS.                                                     | 1               |
|     | <b>Total Hours</b>                                                     | <b>48 Hours</b> |



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FOURTH SEMESTER B TECH DEGREE EXAMINATION (HONOURS),  
DECEMBER 2024**

**Course Code: B24ECH41**

**Course Name: NANO ELECTRONICS**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Explain any three characteristic lengths in mesoscopic systems.
2. Explain the terms (i) coherence length (ii) phase coherence.
3. Differentiate dry and wet oxidation.
4. DC sputtering cannot be used for coating of non-conducting materials. Justify.
5. Explain two different modes of operation of a STM.
6. Explain XRD method for characterizing nano materials.
7. Differentiate between the two types of multiple quantum wells.
8. Explain Aharonov-Bohm effect.
9. Explain why MODFETs are called high electron mobility transistors.
10. List any six properties of graphene.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Show that DOS in a 2D material is independent of energy. (8)  
b) Explain any three physical limitations in reducing the size of devices in Nano metric scale. (6)
12. Compare and contrast square, parabolic and triangular quantum wells (14)

**Module II**

13. a) Illustrate the process of Molecular Beam Epitaxy for fabricating nano layers. (8)  
b) Differentiate between dry oxidation and wet oxidation techniques (6)
14. a) Sketch and label a CVD reactor and explain the different steps involved in the CVD process. (8)  
b) Explain the reduction method for nano particle fabrication (6)

**Module III**

15. Explain the different specimen interactions of an electron beam and illustrate the working of a SEM (14)
16. Explain the principle of operation of an AFM. Explain the different modes of operation. (14)

**Module IV**

17. a) Explain Kronig–Penney model of a super lattice. What is meant by Zone folding? (10)  
b) Explain the concept of hot electrons in parallel transport (4)
18. a) Explain Coulomb Blockade effect. (8)  
b) Explain the concept of hot electrons in parallel transport (6)

**Module V**

19. a) Draw the schematic and explain the working of a single electron transistor. (8)  
b) Explain working of resonant tunneling diodes (6)
20. a) Illustrate the working of a quantum well laser (6)  
b) Explain the different types of Carbon Nanotube transistors (8)

| B24ECH42 | STOCHASTIC PROCESSES FOR COMMUNICATION (Honours) | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|----------|--------------------------------------------------|---|---|---|---|--------|----------------------|
|          |                                                  | 3 | 1 | 0 | 5 | 4      | 2024                 |

### Preamble

This course aims to apply the concepts of probability and random processes in communication systems.

**Prerequisites :** None

### Course Outcomes:

After the completion of the course the student will be able to

|             |                                                                                                             |
|-------------|-------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Explain the concepts of probability, random variables and stochastic processes[Remember]                    |
| <b>CO 2</b> | Apply the knowledge in probability to statistically characterize communication channels.[Understand, Apply] |
| <b>CO 3</b> | Apply probability to find the information and entropy[Understand, Apply]                                    |
| <b>CO 4</b> | Explain source coding and channel coding theorem. [Remember]                                                |
| <b>CO 5</b> | Apply stochastic processes in data transmission.[Understand, Apply]                                         |

### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 3    |      |      |      |      |      |      |      |       |       |
| <b>CO 2</b> | 3    | 3    |      | 3    | 2    |      |      |      |      |       |       |
| <b>CO 3</b> | 3    | 3    |      | 3    | 2    |      |      |      |      |       | 2     |
| <b>CO 4</b> | 3    | 3    |      |      |      |      |      |      |      |       |       |
| <b>CO 5</b> | 3    | 3    |      | 3    | 2    |      |      |      |      |       |       |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 30                    | 30              | 30                                 |
| Understand       | 40                    | 40              | 40                                 |
| Apply            | 30                    | 30              | 30                                 |

### Mark Distribution



| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1): Concepts in probability

1. Give frequentist and axiomatic definitions of probability. State the demerits of frequentist definition.
2. What is a random variable? Illustrate with an example how it becomes useful in studying engineering problems?
3. A six faced die with  $P(1)=P(3)=1/3$ ,  $P(4)=P(5)=1/4$  is thrown in a game with outcomes listed in the table.

| Face        | 1  | 2   | 3  | 4   | 5   | 6   |
|-------------|----|-----|----|-----|-----|-----|
| Payoff (Rs) | 50 | -40 | 60 | -60 | -20 | 100 |

The + and - signs indicate gain and loss for the player, respectively.

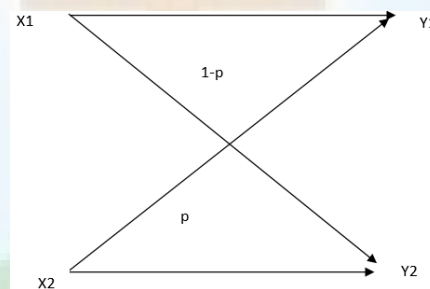
1. Draw the CDF and PDF
2. Compute the expected value of gain/loss. Is it worthwhile to play the game?
3. Compute the entropy of the random variable.

#### Course Outcome 2 (CO 2): Review of random processes

1. Give the conditions for WSS and SSS.
2. Test if the sinusoid  $X(t) = A \cos(2\pi f t + \theta)$  with  $\theta$  varying uniformly in the interval  $[-\pi, \pi]$  is WSS.
3. Define white Gaussian noise.
4. State central limit theorem. Why is the Gaussian model suitable in additive noise channels?

### **Course Outcome 3 (CO 3): Entropy and Information**

1. Define discrete memoryless source and discrete memoryless channel.
2. Define entropy and conditional entropy.
3. See the binary symmetric channel in the figure below.  
Let  $p(x_1) = 1/3$  and  $p = 1/4$ . Compute the mutual information between X and Y.



### **Course Outcome 4 (CO 4): Source coding and Channel Coding**

1. State the source coding theorem.
2. Compute the mutual information between the input and output of an AWGN channel. What is its capacity?
3. Find the capacity of an AWGN channel with 4kHz bandwidth and the noise power spectral density  $10^{-12} \text{ W/Hz}$ . The signal power at the receiver is 0.1mW.

**Course Outcome 5 (CO 5): Stochastic processes in data transmission**

1. Derive Chapman – Kolmogorov equation.
2. Explain the need for spectrum estimation.
3. Explain the packet transmission in a slotted ALOHA network.
4. Consider a Markov chain with three possible states 1,2,3 with transition probability matrix

$$\begin{pmatrix} \frac{1}{4} & \frac{1}{2} & \frac{1}{4} \\ \frac{1}{3} & 0 & \frac{2}{3} \\ \frac{1}{2} & 0 & \frac{1}{2} \end{pmatrix}$$

- (a) Draw the state transition diagram.
- (b) Find  $P(X_4=3|X_3=2)$
- (c) If  $P(X_0=1)=1/3$  Find  $P(X_0=1, X_1=2)$

**SYLLABUS**

**Module 1 :**

Review of probability. Relative frequency and Axiomatic definitions of probability, Significance of axiomatic definition. Bayes theorem and conditional probability. Independence. Discrete random variables. The cumulative distribution and density functions for discrete random variables. Joint distribution and conditional distribution. Statistical averages. Mean, Variance and standard deviation, Gaussian density function, Pdf of envelop of two gaussian variables.

**Module 2 :**

Stochastic Processes. Stationarity and ergodicity. WSS and SSS processes. Gaussian Random process, Mean and autocorrelation and power spectral density functions. Weiner Kinchine theorem, Bandwidth of a random process, PSD of a Pulse Amplitude Modulated wave. White noise, Filtering of discrete WSS process by LTI systems. Noise-equivalent bandwidth, Signal to Noise Ratio, Matched Filter, Bandlimited and narrowband random process.

Sum of random variables, The central limit theorem (statement only). Gaussianity of thermal noise.

**Module 3:**

Basics of discrete communication system, Sources, channels and receivers. Discrete memoryless sources. Entropy. Source coding theorem (statement only). Mutual Information. Discrete memoryless channels. Matrix of channel transmission probabilities. Noiseless and

noisy channels, binary symmetry channels. Channel coding theorem (statement only) Channel capacity for BSC (derivation required), Differential entropy, Channel capacity of AWGN channel (statement only).

#### Module 4 :

Markov process. Definition and model. Markov chain. Transition probability matrix. State diagram and characteristics of a Markov chain. Chapman Kolmogorov equation. Poisson process.

#### Module 5 :

Overview of queuing theory. M/M/1, M/M/ $\infty$ , Application to packet transmission in a slotted ALOHA computer communication network.

#### Text Books

1. Papaulis and Unnikrishna Pillai, “Probability, Random Variables and Stochastic Processes”, MH.
2. Analog and Digital Communication Systems, Hsu, Schaum Outline Series, MGH.
3. Digital Communication, John G Proakis, John Wiley.
4. Probability and Random Processes, Miiller and Childers, Ed. 2, Academic Press.
5. Data Networks, Bertsekas and Gallager, Ed. 2, PHI.

### COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                                                       | No of Lecture |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| 1   | <b>Module 1</b>                                                                                                                                                                             | <b>12</b>     |
| 1.1 | Review of probability. Relative frequency and Axiomatic definitions of probability, Significance of axiomatic definition.                                                                   | 2             |
| 1.2 | Conditional probability, Bayes theorem, Meaning and significance of prior. Random variable. Definition. Random variable as a function and its domain. Comparison with probability function. | 2             |
| 1.3 | Examples of RV. Discrete and continuous RV. CDF and PDF of RV(both discrete and continuous) Examples. Relation between the two and properties                                               | 1             |
| 1.4 | The cumulative distribution and density functions for discrete random variables. Joint distribution and conditional distribution.                                                           | 3             |
| 1.5 | Statistical averages. Mean, Variance and standard deviation                                                                                                                                 | 2             |
| 1.6 | Gaussian density function, Pdf of envelop of two gaussian variables                                                                                                                         | 2             |
| 2   | <b>Module 2</b>                                                                                                                                                                             | <b>8</b>      |
| 2.1 | Stochastic Processes. Stationarity and ergodicity. WSS and SSS processes. Gaussian Random process                                                                                           | 2             |
| 2.2 | Mean and autocorrelation and power spectral density functions. Weiner Kinchine theorem, Bandwidth of a random process, PSD of a Pulse Amplitude Modulated wave.                             | 2             |

|     |                                                                                                                                                                               |           |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 2.3 | White noise, Filtering of discrete WSS process by LTI systems. Noise- equivalent bandwidth, Signal to Noise Ratio, Matched Filter, Bandlimited and narrowband random process. | 3         |
| 2.4 | Sum of random variables, The central limit theorem (statement only). Gaussianity of thermal noise.                                                                            | 1         |
| 3   | <b>Module 3</b>                                                                                                                                                               | <b>9</b>  |
| 3.1 | Basics of discrete communication system, Sources, channels and receivers.                                                                                                     | 1         |
| 3.2 | Discrete memoryless sources. Entropy. Source coding theorem (statement only).                                                                                                 | 1         |
| 3.3 | Mutual Information. Discrete memoryless channels. Matrix of channel transmission probabilities. Noiseless and noisy channels, binary symmetry channels.                       | 2         |
| 3.4 | Channel coding theorem (statement only) Channel capacity for BSC (derivation required),                                                                                       | 3         |
| 3.5 | Differential entropy, Channel capacity of AWGN channel (statement only).                                                                                                      | 2         |
| 4   | <b>Module 4</b>                                                                                                                                                               | <b>8</b>  |
| 4.1 | Markov process. Definition and model.                                                                                                                                         | 1         |
| 4.2 | Markov chain. Transition probability matrix. State diagram and characteristics of a Markov chain. Chapman Kolmogorov equation.                                                | 4         |
| 4.4 | Poisson process                                                                                                                                                               | 3         |
| 5   | <b>Module 5</b>                                                                                                                                                               | <b>8</b>  |
| 5.1 | Overview of queuing theory.                                                                                                                                                   | 2         |
| 5.2 | M/M/1, M/M/ $\infty$ systems.                                                                                                                                                 | 3         |
| 5.3 | Application to packet transmission in a slotted ALOHA computer communication network.                                                                                         | 3         |
|     | <b>Total Hours</b>                                                                                                                                                            | <b>45</b> |

### Simulation Assignments

The following simulations can be done in Python/R/MATLAB/SCILAB.

#### Generation of Discrete Stochastic Signals

1. Simulate stochastic signals of

- Uniform
- Binomial
- Gaussian
- Rayleigh
- Ricean

probability density functions and test their histograms.

2. Compute the statistical averages such as mean, variance, standard deviation etc.



3. Compute the autocorrelation matrix for each signal. Compare the autocorrelation of Gaussian signal with others.
4. Observe the spectrum of the signal and relate it with the autocorrelation function.

### Central Limit Theorem—Gaussianity of Channels

- Simulate a coin toss experiment that generates a string of length  $N$  of 0s and 1s that are uniformly distributed.
- Toss the coin  $M$  times and sum up the string in every toss.
- Plot the normalized histogram of the sum values for  $M = 100, 1000, 5000$ . Observe that it is a Binomial distribution.
- Plot the function  $q = \binom{M}{r} p^r (1-p)^{M-r}$  and compare with the histogram.
- Make  $M$  very large and observe that the histogram tends to become Gaussian, justifying the central limit theorem.

### Frequency of Characters in English Text and the Entropy

1. Understand the probabilities of occurrence of characters in English text, say an English novel with more than 300 pages (that contains text only) in .txt format. (Students may download one such file.)
2. Read the novel in .txt format into a single string or array, identify the unique symbols (all letters, numbers, punctuation marks, etc.), and plot their frequencies of occurrence.
3. Appreciate the probabilities of occurrences of all symbols.
4. Compute the entropy and the information content in the book.

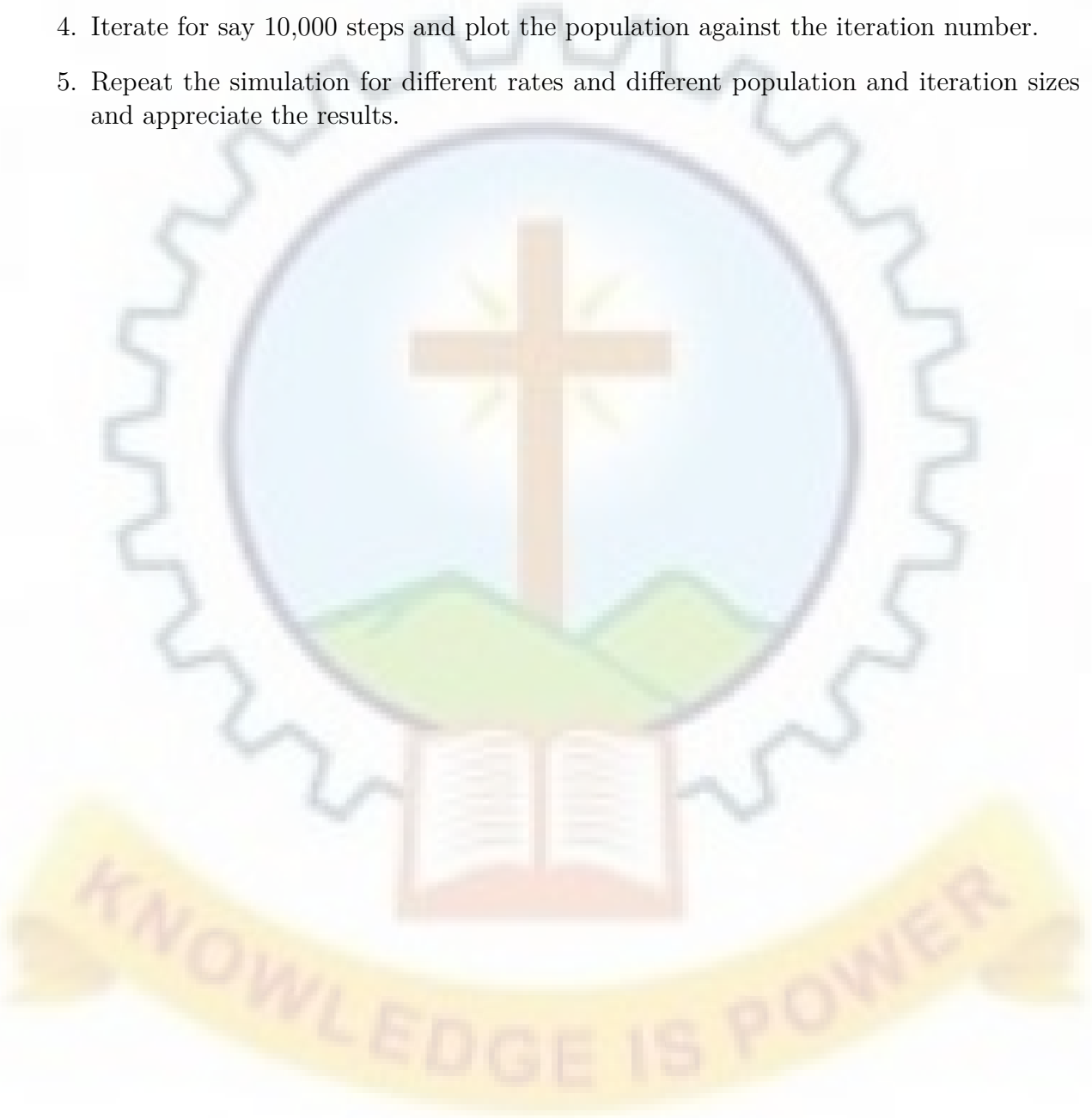
### Simulation of a Point Process

1. It is required to simulate a point Poisson process, say the arrival of packets in a queue.
2. Let the rate of arrival of packets be say 100 per second.
3. Simulate the Poisson process using small time bins of say 1 millisecond.
4. Since Poisson process has no memory, the occurrence of an event is independent from one bin to another.
5. Binary random signals can be used to represent success or failure.
6. Simulate and display each event with a vertical line using say *matplotlib*.
7. Generate the counting process  $N(t)$ , which is the sum of the events until time  $t$ .
8. Plot  $N(t)$  against  $t$  and appreciate it.



## **Simulation of a Discrete Markov Chain**

1. It is required to simulate a birth-death process as a discrete Markov chain.
2. Let us consider that the total population cannot exceed 1000 and the initial population is 100.
3. Set equal birth and death rates.
4. Iterate for say 10,000 steps and plot the population against the iteration number.
5. Repeat the simulation for different rates and different population and iteration sizes and appreciate the results.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FOURTH SEMESTER B TECH DEGREE (HONOURS) EXAMINATION**

**Course Code: B24ECH42**

**STOCHASTIC PROCESSES FOR COMMUNICATION**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Give the three definitions of probability
2. In the toss of an unfair coin, the probability of head is  $\frac{1}{3}$ . Write the conditions for strict sense and wide sense stationarity
3. State central limit theorem. Give its significance.
4. Explain the Gaussian statistics of communication channels
5. State the two source coding theorems
6. Give channel matrix of a noiseless binary channel
7. With mathematical model, explain Markov process
8. Give an example of a Markov chain with its transition probability matrix
9. Explain an M/M/1 queue system in packet transmission
10. Explain the statistics of packet arrival in M/M/1 queue system

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Derive mean and variance of a Gaussian distribution with parameters  $\mu$  and  $\sigma^2$  (8)  
 b) A random variable X has the following pdf. (6)

$$f_X(\lambda) = \begin{cases} \frac{|\lambda|}{8}, & -3 \leq \lambda \leq 3, \\ 0, & \text{else} \end{cases}$$

Find the probability  $P(|\lambda| < 1.5)$

Find the probability  $P(1.2 \leq \lambda \leq 2.3)$

Find  $E[X]$

**OR**

12. a) A six faced die with  $P(1) = P(5) = 1/6$ ,  $P(4) = P(3) = 1/8$ ,  $P(2) = 1/12$  is thrown in a game with outcomes listed in the table. (14)

| Face        | 1  | 2   | 3  | 4   | 5   | 6   |
|-------------|----|-----|----|-----|-----|-----|
| Payoff (Rs) | 50 | -40 | 60 | -60 | -20 | 100 |

The + and- signs indicate gain and loss for the player respectively.

- (i) Draw the CDF and PDF of the Payoff random variable.  
 (ii) Compute the expected value of gain/loss. Is it worthwhile to play the game?  
 (iii) What is the variance of Payoff?

**Module II**

13. a) Test if the random process

$$X(t) = A \cos(2\pi fct + \theta)$$

is WSS with A a random variable in the interval  $[-\pi, \pi]$ . (7)

- b) If a random signal is applied as input to an LTI system, how is the power spectral density of the output related to that of the input? Explain. (7)

**OR**

14. (a) State and prove Wiener Kinchine theorem. (8)  
 (b) Justify the suitability of using white Gaussian model for noise in a communication system. (6)

**Module III**

15. a) State source coding theorem for a discrete memoryless source. (6)

- b) Show that mutual information is always positive. (3)
- c) What is channel capacity in terms of the conditional entropy? Write down the capacity of an AWGN channel. (5)

**OR**

16. (a) Define entropy of a discrete memoryless source. If the alphabet is finite with size  $K$ , show that  $H(X) \leq \log_2 K$  (6)
- (b) For the binary channel below, compute the channel transition matrix and  $P(Y_0)$  and  $P(Y_1)$ , given that  $P(X_0) = P(X_1) = 0.5$  (8)

**Module IV**

17. (a) Explain a Poisson random process. Give two practical examples of a Poisson process (7)
- (b) Derive Chapman – Kolmogorov equation. (7)

**OR**

18. Consider a Markov chain with three possible states 1,2,3 with transition probability matrix
- (a) Draw the state transition diagram. (4)
- (b) Find  $P(X_4 = 3 | X_3 = 2)$  (5)
- (c) If  $P(X_0 = 1) = \frac{1}{3}$ , find  $P(X_0 = 1, X_1 = 2)$  (5)

**Module V**

19. Explain the packet transmission in a slotted ALOHA network (14)

**OR**

20. Explain the M/M/1 queue system pertaining to packet transmission (14)

| B24ECH43 | STOCHASTIC<br>SIGNAL<br>PROCESSING<br>(Honours) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|----------|-------------------------------------------------|---|---|---|---|--------|-------------------------|
|          |                                                 | 3 | 1 | 0 | 5 | 4      | 2024                    |

### Preamble

This course aims to study stochastic signals and their interactions with LTI systems

### Prerequisites

Nil

### Course Outcomes

After the completion of the course the student will be able to:

|      |                                                                                                 |
|------|-------------------------------------------------------------------------------------------------|
| CO 1 | Explain the concepts of probability, random variables and stochastic processes [Understand]     |
| CO 2 | Apply the knowledge in probability to statistically characterize communication channels [Apply] |
| CO 3 | Use the properties of WSS for finding the LTI system response [Remember,Apply]                  |
| CO 4 | Model discrete signals using various methods [Understand]                                       |
| CO 5 | Estimate the spectra of signals using various methods [Understand, Apply]                       |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 3    |      |      |      |      |      |      |      |       |       |
| CO 2 | 3    | 3    |      | 3    | 2    |      |      |      |      |       |       |
| CO 3 | 3    | 3    |      | 3    | 2    |      |      |      |      |       |       |
| CO 4 | 3    | 3    |      |      |      |      |      |      |      |       |       |
| CO 5 | 3    | 3    |      | 3    | 2    |      |      |      |      |       |       |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 30                    | 30              | 30                                 |
| Understand       | 40                    | 40              | 40                                 |
| Apply            | 30                    | 30              | 30                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.



## SYLLABUS

### MODULE 1

**Review of Probability and Random Variables:** Review of probability, Relative frequency and Axiomatic definitions of probability, Significance of axiomatic definition. Bayes theorem and conditional probability. Independence. Discrete random variables. The cumulative distribution and density functions for random variables. Joint distribution and conditional distribution. Statistical averages. Mean, Variance and standard deviation, Functions of random variables. Multivariate Gaussian density function.

### MODULE 2

**Review of Random Processes :** Stochastic Processes, Stationarity and ergodicity, WSS and SSS processes, Discrete Gaussian, Rayleigh and Ricean processes, Sums of random variables, Convergence, Markov and Chebyshev inequality, The central limit theorem (statement only).

### MODULE 3

**The Autocorrelation Matrix and its Significance:** Statistical averages of discrete stationary stochastic processes, Mean and autocorrelation and power spectral density functions, Weiner Kinchine theorem, Filtering of discrete WSS process by LTI systems, The autocorrelation matrix and the significance of its eigen vectors, Whitening, Properties of autocorrelation matrix, its inversion, Wiener-Hopf equation, Brownian motion, its mathematical model and its autocorrelation and power spectral density.

### MODULE 4

**Signal Modeling – Deterministic and Stochastic:** The least squares method of signal modeling, The Pade approximation. Prony's method, Stochastic models, AR, MA and ARMA models

### MODULE 5

**Spectrum Estimation :** Periodogram method of spectrum estimation, Parametric methods AR, MA and ARMA methods

**Text Books**

1. Monson Hayes, "Statistical Digital Signal Processing", Wiley
2. A. Papaulis and Unnikrishna Pillai, "Probability, Random Variables and Stochastic Processes", McGraw Hill

**References**

1. Peyton Z. Peebles, "Probability, Random Variables & Random Signal Principles ", MC GRAW HILL EDUCATION, 4th Edition, 2001



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                                                       | No of Lecture/Tutorial Hours |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                                                             | <b>10</b>                    |
| 1.1 | The three definitions. Critique to classical definition. Probability as a function. The domain of probability function. Event and probability space                                         | 2                            |
| 1.2 | Conditional probability, Bayes theorem, Meaning and significance of prior. Random variable. Definition. Random variable as a function and its domain. Comparison with probability function. | 2                            |
| 1.3 | Examples of RV. Discrete and continuous RV. CDF and PDF of RV(both discrete and continuous) Examples. Relation between the two and properties                                               | 1                            |
| 1.4 | Uniform and Gaussian Pdf and corresponding CDF. Properties, Expectation, variance and standard deviation, Examples                                                                          | 3                            |
| 1.5 | Functions of random variables.                                                                                                                                                              | 2                            |
|     | <b>Module 2</b>                                                                                                                                                                             | <b>9</b>                     |
| 2.1 | Stochastic process, Definition. Stationarity and ergodicity                                                                                                                                 | 2                            |
| 2.2 | WSS and SSS conditions. Example problems                                                                                                                                                    | 2                            |
| 2.3 | Sums of random variables, Convergence, Markov and Chebyshev inequality                                                                                                                      | 2                            |
| 2.4 | Gaussian Process. Envelope of Gaussian process. Rayleigh pdf. Example                                                                                                                       | 2                            |
| 2.5 | Central limit theorem. Application in AWGN channel                                                                                                                                          | 1                            |
|     | <b>Module 3</b>                                                                                                                                                                             | <b>12</b>                    |
| 3.1 | Expectation, variance, autocorrelation and power spectral density                                                                                                                           | 2                            |
| 3.2 | Autocorrelation matrix, properties eigen values                                                                                                                                             | 2                            |
| 3.3 | Filtering of WSS, output autocorrelation and PSD                                                                                                                                            | 2                            |
| 3.4 | Inversion of autocorrelation matrix. LD recursion                                                                                                                                           | 2                            |
| 3.5 | Whitening                                                                                                                                                                                   | 1                            |
| 3.6 | Wiener Hopf equation, Brownian motion. Model and spectral density                                                                                                                           | 3                            |
|     | <b>Module 4</b>                                                                                                                                                                             | <b>8</b>                     |
| 4.1 | Least squares method                                                                                                                                                                        | 2                            |
| 4.2 | Pade method, Prony method                                                                                                                                                                   | 3                            |
| 4.3 | Stochastic models                                                                                                                                                                           | 3                            |
|     | <b>Module 5</b>                                                                                                                                                                             | <b>7</b>                     |
| 5.1 | Periodogram                                                                                                                                                                                 | 3                            |
| 5.2 | Parametric methods                                                                                                                                                                          | 4                            |
|     | <b>Total Hours</b>                                                                                                                                                                          | <b>46 Hours</b>              |

## CO ASSESSMENT QUESTIONS

### Course Outcome 1 (CO 1):

1. Give frequentist and axiomatic definitions of probability. State the demerits of frequentist definition.
2. What is a random variable? With an example, illustrate how it finds application in defining engineering problems?

### Course Outcome 2 (CO 2):

1. State central limit theorem. Explain the validity of using Gaussian model for additive communication channels.
2. Give the conditions for WSS and SSS.

### Course Outcome 3 (CO 3):

1. Derive Wiener Hopf equations.
2. Solve Wiener-Hopf equation to get a third order discrete system for a an RV X whose autocorrelation is  $R_x=[0.89,0.75,0.7,0.6]$

### Course Outcome 4 (CO 4):

1. Use Prony method to model a unit pulse  $x[n]=U[n]-U[n-N]$  as a system with one pole and one zero.
2. Use Pade approximation to model the signal x whose first six values are  $[1,1.2,0.9,0.5,0.6,0.25]$  using a second order all pole model ( $p=2$  and  $q=0$ )

### Course Outcome 5 (CO 5):

1. Explain the periodogram method of spectrum estimation
2. Explain the need of spectrum estimation

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 3**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FOURTH SEMESTER B TECH DEGREE (HONOURS) EXAMINATION**

**Course Code: B24ECH43**

**Course Name: STOCHASTIC SIGNAL PROCESSING**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. State the three axioms of probability.
2. You throw a coin and if head turns up you get Rs. 100 and loses Rs. 40 if tails turns up. The probability of a head is 0:2. Draw the CDF and PDF of the random variable representing gain/loss.
3. State central limit theorem. Give its significance.
4. Draw the pdf of Rayleigh density function.
5. Write and explain the differential equation for Brownian motion.
6. Give the output mean and autocorrelation of a an LTI system that is driven by a WSS process.
7. Explain the term signal modeling.
8. Explain ARMA model of a signal.
9. Explain the need for power spectrum estimation.
10. List the various parametric spectrum estimation methods.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Derive mean and variance of a Gaussian distribution with parameters  $\mu$  and  $\sigma^2$ . (8)
- b) Write down the probability density of a bivariate Gaussian random variable. What is the significance of the correlation coefficient? (6)

or

12. A six faced die with  $P(1) = P(5) = \frac{1}{6}$ ,  $P(4) = P(3) = \frac{1}{8}$ ,  $P(2) = \frac{1}{12}$  is thrown in a game with outcomes listed in the table.

|        |    |     |    |     |     |     |
|--------|----|-----|----|-----|-----|-----|
| Face   | 1  | 2   | 3  | 4   | 5   | 6   |
| Payoff | 50 | -40 | 60 | -60 | -20 | 100 |

The + and - signs indicates gain and loss for the the player respectively.

- a) Draw the CDF and PDF of Payoff random variable. (6)
- b) Compute the expected value of gain/loss. Is it worthwhile to play the game? What is the variance of Payoff? (8)

**Module II**

13. a) Test if the random process  $X(t) = A \cos(2\pi f_c t + \theta)$  is WSS with A a random variable in the interval  $[-\pi, \pi]$  (7)
- b) If X and Y are zero mean Gaussian RVs, compute the pdf of  $Z = \sqrt{X^2 + Y^2}$  (7)

or

14. a) Express a Binomial random variable X as a sum of many Bernoulli random variables. Derive the mean of X using this connection. List the conditions for a stochastic process to be WSS. (8)
- b) Derive Chebyshev inequality. How is it helpful in estimating tail probabilities? (6)

**Module III**

15. a) State and prove three properties of autocorrelation matrix. (8)
- b) Prove that the power spectrum of a real process X(t) is real. (6)

or

16. Give the mathematical model and compute the autocorrelation of the Brownian motion. (14)



**Module IV**

17. Use Pade approximation to model the signal  $x$  whose first six values are  $[1, 1.6, 0.7, 0.4, 0.6, 0.25]$  using a second order all pole model ( $p = 2$  and  $q = 0$ ) and a second order MA model ( $p = 0$  and  $q = 2$ ). (14)

or

18. Use Prony method to model a unit pulse  $x[n] = U[n] - U[n-N]$  as a system with one pole and one zero. (14)

**Module V**

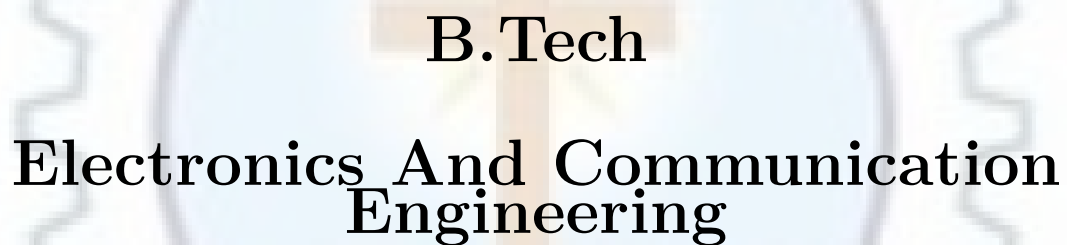
19. Explain the periodogram method of spectrum estimation. (14)

or

20. Explain the three nonparametric methods of spectrum estimation. (14)

# **MAR ATHANASIUS COLLEGE OF ENGINEERING**

Government Aided, Autonomous Institution, Kothamangalam, Kerala,  
India

The logo of Mar Athanasius College of Engineering is a circular emblem. It features a large gear-like outer border. Inside the circle, there is a blue upper half and a green lower half. A brown cross is centered in the blue area, with a yellow sunburst at its intersection. Below the cross, there are green hills. At the bottom of the emblem, there is a yellow banner with the text 'KNOWLEDGE IS POWER' in red capital letters.

## **B.Tech Electronics And Communication Engineering**

### **SEMESTER 5**

#### **SYLLABUS**

**SEMESTER 5**

| SLOT         | COURSE NO. | COURSES                          | L-T-P-S | HOURS     | CREDIT    |
|--------------|------------|----------------------------------|---------|-----------|-----------|
| A            | B24EC3T01  | Digital Signal Processing        | 3-1-0-5 | 4         | 4         |
| B            | B24EC3T02  | Control Systems                  | 3-1-0-5 | 4         | 4         |
| C            | B24EC3T03  | Analog And Digital Communication | 3-1-0-5 | 4         | 4         |
| D            | B24EC3T04  | VLSI Design                      | 3-1-0-5 | 4         | 4         |
| E            | B24EC3T05  | Embedded Systems                 | 2-1-0-4 | 3         | 3         |
| F            | B24EC3P1X  | Programme Elective I             | 2-1-0-4 | 3         | 3         |
| G            | B24EC3L07  | Linear Integrated Circuits Lab   | 0-0-3-2 | 3         | 2         |
| H            | B24EC3L08  | Control Systems Lab              | 0-0-3-2 | 3         | 2         |
| M            | B24ECM5X   | Minor                            | 3-1-0-5 | 4         | 4         |
| N            | B24ECH5X   | Honours                          | 3-1-0-5 | 4         | 4         |
| <b>TOTAL</b> |            |                                  |         | <b>36</b> | <b>26</b> |

**PROGRAMME ELECTIVE I**

| COURSE NO | Courses                                   |
|-----------|-------------------------------------------|
| B24EC3P11 | Scientific Computing Using Python         |
| B24EC3P12 | Instrumentation And Industrial Automation |
| B24EC3P13 | Optical Fiber Communication               |
| B24EC3P14 | Digital System Design                     |
| B24EC3P15 | Chip Fabrication Technology               |

**MINOR**

| COURSE NO | Courses                                  |
|-----------|------------------------------------------|
| B24ECM51  | Embedded System Design                   |
| B24ECM52  | Communication Systems                    |
| B24ECM53  | Introduction To Digital Image Processing |

**HONOURS**

| COURSE NO | Courses                                    |
|-----------|--------------------------------------------|
| B24ECH51  | System Verilog For Design And Verification |
| B24ECH52  | Detection And Estimation Theory            |
| B24ECH53  | Computational Tools For Signal Processing  |

| <b>B24EC3T01</b> | <b>DIGITAL SIGNAL PROCESSING</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF INTRODUCTION</b> |
|------------------|----------------------------------|----------|----------|----------|----------|---------------|-----------------------------|
|                  |                                  | 3        | 1        | 0        | 5        |               |                             |

**Preamble**

This course is designed to give students a clear understanding of the principles, algorithms, and applications of Digital Signal Processing (DSP).

**Prerequisites**

B24EC2T05 Signals and Systems

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                                                                                  |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | State and prove the fundamental properties and relations relevant to DFT and solve basic problems involving DFT based filtering methods.[Understand, Apply]                                                                      |
| <b>CO 2</b> | Use FFT algorithms for calculating DFT and IDFT.[Understand, Apply]                                                                                                                                                              |
| <b>CO 3</b> | Design linear phase FIR filters and IIR filters for a given specification.[Remember , Apply]                                                                                                                                     |
| <b>CO 4</b> | Implement FIR and IIR filter for the given system function.[Understand,Apply]                                                                                                                                                    |
| <b>CO 5</b> | Understand the basic multi-rate DSP operations such as decimation and interpolation and finite word length effects in DSP systems,also DSP processor and the difference between general purpose processors.[Understand, Analyze] |

**Mapping of Course Outcomes With Program Outcomes**

|             | <b>PO 1</b> | <b>PO 2</b> | <b>PO 3</b> | <b>PO 4</b> | <b>PO 5</b> | <b>PO 6</b> | <b>PO 7</b> | <b>PO 8</b> | <b>PO 9</b> | <b>PO 10</b> | <b>PO 11</b> |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|
| <b>CO 1</b> | 3           | 2           | 2           |             | 2           |             |             |             |             |              | 2            |
| <b>CO 2</b> | 3           | 3           | 3           |             | 3           |             |             |             |             |              | 2            |
| <b>CO 3</b> | 3           | 2           | 3           |             | 3           |             |             |             |             |              | 2            |
| <b>CO 4</b> | 3           | 2           | 2           |             | 3           |             |             |             |             |              | 2            |
| <b>CO 5</b> | 2           | 2           | 2           |             | 2           |             |             |             |             |              | 2            |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 30                    | 30                 | 30                                    |
| Apply            | 50                    | 50                 | 50                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Transform and Filtering in Signal Processing:** Basic Elements of a DSP system, Typical DSP applications. The Discrete Fourier Transform: DFT as a linear transformation (Matrix relations), Relationship of the DFT to other transforms, IDFT, Properties of DFT and examples. Circular convolution, Linear Filtering methods based on the DFT, linear convolution using circular convolution. Filtering of long data sequences, overlap save and overlap add methods, Frequency Analysis of Signals using the DFT (only concept is required)

### MODULE 2

**Fast Fourier Transform and Applications :** Efficient Computation of DFT: Fast Fourier Transform Algorithms-Radix-2 Decimation in Time and Decimation in Frequency FFT Algorithms, IDFT computation using Radix-2 FFT Algorithms, Application of FFT Algorithms, Efficient computation of DFT of Two Real Sequences and a  $2N$ -Point Real Sequence.

### MODULE 3

**Design of FIR Filters:** Symmetric and Anti-symmetric FIR Filters, Design of linear phase FIR filters using Window methods, (rectangular, Hamming and Hanning) and frequency sampling method, Comparison of design methods for Linear Phase FIR Filters. Design of IIR filters-Digital . Impulse Invariance, and Bilinear Transformation, Frequency Transformations in the Analog and Digital Domain.Design of IIR filters from Analog Filters (Butterworth).

### MODULE 4

**Structures for the realization of Discrete Time Systems :** Block diagram and signal flow graph representations of filters, FIR Filter Structures: Linear structures, Direct Form, Cascade Form. IIR Filter Structures: Direct Form, Transposed Form, Cascade Form and Parallel Form, Computational Complexity of Digital filter structures.

### MODULE 5

**Multi-rate Digital Signal Processing and Finite word length effects in DSP systems:** Decimation and Interpolation (Time domain and Frequency Domain Interpretation ), Anti- aliasing and anti-imaging filter. Finite word length effects in DSP systems: Introduction (analysis not required), fixed-point and floating-point DSP arithmetic, ADC quantization noise, Finite word length effects in IIR digital filters: coefficient quantization errors. Finite word length effects in FFT algorithms: Round off errors. Introduction to TMS320C67xx digital signal processor(Only Features required).

### Text Books

1. Proakis J. G. and Manolakis D. G., Digital Signal Processing, 4/e, Pearson Education, 2007



2. “Alan V Oppenheim, Ronald W. Schafer ,Discrete-Time Signal Processing, 3rd Edition ,Pearson ,2010
- 3.“Mitra S. K., Digital Signal Processing: A Computer Based Approach, 4/e McGraw Hill (India) 2014
- 4.Ifeachor E.C. and Jervis B. W., Digital Signal Processing: A Practical Approach, 2/e Pearson Education, 2009.

### **COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                                                                                          | <b>No of Lec-<br/>ture/Tuto-<br/>rial Hours</b> |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|
|           | <b>Module 1</b>                                                                                                                                                                       | <b>8</b>                                        |
| 1.1       | Basic Elements of a DSP system, Typical DSP applications                                                                                                                              | 1                                               |
| 1.2       | The Discrete Fourier Transform: DFT as a linear transformation (Matrix relations)                                                                                                     | 1                                               |
| 1.3       | Relationship of the DFT to other transforms, IDFT                                                                                                                                     | 2                                               |
| 1.4       | Properties of DFT and examples.                                                                                                                                                       | 1                                               |
| 1.5       | Circular convolution, Linear Filtering methods based on the DFT, linear convolution using circular convolution.                                                                       | 1                                               |
| 1.6       | Filtering of long data sequences, overlap save and overlap add methods                                                                                                                | 1                                               |
| 1.7       | Frequency Analysis of Signals using the DFT                                                                                                                                           | 1                                               |
|           | <b>Module 2</b>                                                                                                                                                                       | <b>8</b>                                        |
| 2.1       | Fast Fourier Transform Algorithms-Radix-2 Decimation in Time                                                                                                                          | 2                                               |
| 2.2       | Decimation in Frequency FFT Algorithms                                                                                                                                                | 2                                               |
| 2.3       | IDFT computation using Radix-2 FFT Algorithms                                                                                                                                         | 2                                               |
| 2.4       | Application of FFT Algorithms, Efficient computation of DFT of Two Real Sequences and a 2N-Point Real Sequence                                                                        | 2                                               |
|           | <b>Module 3</b>                                                                                                                                                                       | <b>10</b>                                       |
| 3.1       | Symmetric and Anti-symmetric FIR Filters                                                                                                                                              | 2                                               |
| 3.2       | Design of linear phase FIR filters using Window methods, (rectangular, Hamming and Hanning) and frequency sampling method, Comparison of design methods for Linear Phase FIR Filters. | 3                                               |
| 3.3       | Impulse Invariance-Frequency Transformations in the Analog and Digital Domain.                                                                                                        | 1                                               |
| 3.4       | Bilinear Transformation, Frequency Transformations in the Analog and Digital Domain                                                                                                   | 1                                               |
| 3.5       | Design of IIR filters from Analog Filters (Butterworth)                                                                                                                               | 3                                               |
|           | <b>Module 4</b>                                                                                                                                                                       | <b>7</b>                                        |

|     |                                                                                                                                                              |                 |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 4.1 | Block diagram and signal flow graph representations of filters, FIR Filter Structures: Linear structures, Direct Form, CascadeForm                           | 3               |
| 4.2 | IIR Filter Structures: Direct Form, Transposed Form, Cascade Form and Parallel Form                                                                          | 3               |
| 4.3 | Computational Complexity of Digital filter structures.                                                                                                       | 1               |
|     | <b>Module 5</b>                                                                                                                                              | <b>9</b>        |
| 5.1 | Multi-rate Digital Signal Processing:Decimation and Interpolation (Time domain and Frequency Domain Interpretation ),Anti- aliasing and anti-imaging filter. | 3               |
| 5.2 | Finite word length effects in DSP systems: Introduction (analysis not required), fixed-point and floating-point DSP arithmetic, ADC quantization noise       | 3               |
| 5.3 | Finite word length effects in IIRdigital filters: coefficient quantization errors. Finite word length effects in FFT algorithms: Round off errors            | 2               |
| 5.4 | Introduction to TMS320C67xx digital signal processor(Only Features required).                                                                                | 1               |
|     | <b>Total Hours</b>                                                                                                                                           | <b>42 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. DFT of a real valued signal  $X(k)$ . =  $j$ ,  $1+j$ ,  $A$ ,  $1-j$ ,  $-1$ ,  $B$ ,  $-1-j$ ,  $C$ . Find the energy of the signal?
2. Determine the circular convolution of the following sequences,  $x(n) = 1, 2, 3, 1$  and  $h(n) = 4, 3, 2, 2$
3. Obtain linear convolution of the sequences  $x(n) = 1, 2, 3$  &  $h(n) = -1, -2$  using circular convolution.

#### Course Outcome 2 (CO 2):

1. Discuss the need for FFT. Justify your answer in terms of computational complexity, memory requirement etc.
2. Find the DFT of the sequence using DIT FFT algorithm  $x[n] = 1, -1, 0$ .
3. Draw the flow diagram of 16 point radix – 2 DIT FFT algorithm

#### Course Outcome 3 (CO 3):

1. Describe the need for employing window technique for FIR filter design?
2. Derive the mapping between  $s$  and  $z$  in bilinear transformation.
3. What are the advantages of frequency sampling technique in FIR filter design?

**Course Outcome 4 (CO 4):**

1. Draw the direct form realization of FIR system.
2. What is Cascade implementation of IIR filter?
3. What is a linear phase filter? What conditions are to be satisfied by an FIR filter in order to have linear phase?

**Course Outcome 5 (CO 5):**

1. What is multirate signal processing? Obtain interpolated and decimated versions for the sequence  $x[n] = 1, 2, 3, 4, 5, 6, 7, 8$  by a factor 2.
2. Give any three differences between DSP processor and general purpose microprocessors.
3. Write down any three applications of DSP processor.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 3**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2026**

**Course Code: B24EC3T01**

**Course Name: DIGITAL SIGNAL PROCESSING**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Compute the DFT of the sequence  $x[n] = (1/2)^n \sum_{k=0}^3 (n-k)$ .
2. Obtain linear convolution of the sequences  $x(n) = \{1, 2, 3\}$  &  $h(n) = \{-1, -2\}$  using circular convolution.
3. Find the number of complex multiplications involved in the calculation of a 64-point DFT using (i) direct computation (ii) radix-2 FFT algorithm.
4. FFT algorithm is an in-place algorithm. Justify it?
5. Compare FIR and IIR filters.
6. Analog transfer function of a digital filter is given by  $(s) = 1/s+3$ . Comment on the stability of the filter. Obtain the digital transfer function of the same using impulse invariance method. Where sampling time is T.
7. Why antialiasing filter is used in decimating systems?
8. Calculate the number of multiplications, additions and delay elements required in the direct form II realization of following system,  $y(n) = 3y(n-1) + 2y(n-2) + 4x(n) + 0.4x(n-1) + 0.8x(n-2)$
9. The effect of ADC quantization noise plays very important role in DSP processors. Justify.
10. Obtain the floating point arithmetic representation of numbers 6.5 and 1.5?

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Find the 4-DFT of the sequence  $x(n) = 6 + \sin(2\pi n/N)$  (5)  
b) Find the convolution of  $x(n) = \{2, 1, -1, -2, -3, 5, 6, -1, 2, 0, 2, 1\}$  and  $h(n) = \{3, 2, 1\}$  using overlap save method? (9)
12. a) Obtain the response of an LTI system with impulse response  $h(n) = \{1, 1, 1\}$  for an input  $x(n) = \{1, 2, 3, 1\}$  using circular convolution? (5)  
b) Given two sequences  $x_1(n) = \{0, 1, 2, 3, 4\}$ ,  $y(n) = \{1, 0, 0, 0, 0\}$ ; Determine a sequence  $x_2(n)$  so that  $Y(k) = X_1(k) X_2(k)$  (9)

**Module II**

13. a) Given  $x(n) = (n + 1)$  for  $0 \leq n \leq 7$ . Find  $X(k)$  using DIT – FFT algorithm. (8)  
b) Compare DIT and DIF algorithms. (6)
14. a) Explain how a  $2N$  point DFT of a  $2N$  point real-valued sequence can be found by computing a single  $N$  point DFT. (6)  
b) Find the IDFT of the sequence  $X(k) = \{4, 1 - j2.414, 0, 1 - j0.414, 0, 1 + j0.414, 0, 1 + j2.414\}$  using DIF – FFT algorithm (8)

**Module III**

15. a) Design a lowpass Butterworth digital filter to give response for 3dB or less for frequencies upto 2kHz and an attenuation of 20dB or more beyond 4kHz. Use the bilinear transformation technique and obtain  $H(z)$  of the desired filter. (10)  
b) What is Gibb's phenomenon? (4)
16. a) For the desired frequency response,  $H_d(w) = e^{-j3w}$  for  $w$  lies between  $-\pi/4$  and  $\pi/4$  and  $H_d(w) = 0$ , otherwise. Determine for  $N = 7$  using rectangular window. (8)  
b) Explain the principle of frequency sampling technique for FIR filter design. (6)

**Module IV**

17. a) Obtain direct form I, direct form II and parallel form structure for the system,  $y(n) = 0.5y(n - 1) + 0.25y(n - 2) + x(n) + x(n - 1)$  (10)  
b) Find the impulse response of a filter given by  $H(z) = 1 - z^{-1} + 2z^{-2} + 3z^{-3} + 5z^{-4}$ . Does this represent a linear phase realization? Comment. (4)

18. a) Realize the system function using minimum number of multipliers  $H(z) = (1 + z^{-1})(1 + 0.5z^{-1} + 0.5z^{-2} + z^{-3})$  (5)
- b) Obtain the cascade and parallel form realization for the system  
 $y(n) = -0.1y(n-1) + 0.2y(n-2) + 3x(n) + 3.6x(n-1) + 0.6x(n-2)$  (9)

**Module V**

19. a) Represent the output of a signal being upsampled by a factor of 3, then down sampled by a factor of 12 followed by upsampled by a factor of 4 . (7)
- b) What is aliasing in Multi-rate signal processing. What is the use of Anti-aliasing filter? Explain. (7)
20. a) Explain the effect of coefficient quantization in IIR and FIR filters? (8)
- b) If quantization noise has uniform distribution with zero mean, find the quantization noise in ADC with step size  $\Delta$ ? (6)



| B24EC3T02 | CONTROL SYSTEMS | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|-----------------|---|---|---|---|--------|----------------------|
|           |                 | 3 | 1 | 0 | 5 | 4      | 2024                 |

### Preamble

This course provides an introduction to the fundamentals of control systems, emphasizing modeling, analysis, and design of feedback systems. It covers mathematical modeling of electrical and mechanical systems, time and frequency domain analysis, stability criteria, and compensator design. The course also introduces state variable methods, focusing on system representation, controllability, and observability.

### Prerequisites

B24EC2T05 : SIGNALS AND SYSTEMS

### Course Outcomes

After the completion of the course, the student will be able to:

|      |                                                                                                                                                                                               |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Describe the fundamental components, structure, and classification of control systems, and represent them using block diagrams and signal flow graphs. [Remember, Understand]                 |
| CO 2 | Explain the time and frequency domain responses of first- and second-order systems and evaluate steady-state errors and performance parameters. [Understand]                                  |
| CO 3 | Apply stability analysis techniques such as the Routh–Hurwitz and root locus methods to study system stability and controller effects. [Apply]                                                |
| CO 4 | Apply frequency response techniques to design lead, lag, and lead–lag compensators for improved system stability and performance. [Apply]                                                     |
| CO 5 | Explain and apply state-space modeling concepts to determine controllability, observability, and relationships between state-space and transfer function representations. [Understand, Apply] |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    |      |      |      |      |      |      |      |       |       |
| CO 2 | 3    | 2    |      |      | 2    |      |      |      |      |       |       |
| CO 3 |      | 3    | 2    | 2    |      |      |      |      |      |       |       |
| CO 4 |      |      | 3    | 2    | 3    |      |      |      |      |       |       |
| CO 5 | 3    |      |      | 3    | 2    |      |      |      |      |       | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 30                    | 30                 | 30                                    |
| Apply            | 50                    | 50                 | 50                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Introduction:** Basic components of a control system, open-loop and closed-loop control systems, examples of control systems. Mathematical modeling of control systems: electrical systems and mechanical systems. Transfer function from block diagrams and signal flow graphs: impulse response and its relation with transfer function of linear systems. Block diagram representation and reduction methods, signal flow graph and Mason's gain formula.

### MODULE 2

**Time Domain and Frequency Domain Analysis:** Standard test signals, time response specifications. Time response of first and second order systems to unit step and ramp inputs, steady state error and static error coefficients. Frequency domain specifications.

### MODULE 3

**Stability and Root Locus Techniques:** Concept of BIBO stability, absolute stability, Routh-Hurwitz criterion, effect of P, PI and PID controllers. Root locus methods: introduction, properties and construction, applications to system stability studies, effect of addition of a zero and a pole.

### MODULE 4

**Frequency Response and Compensator Design:** Nyquist stability criterion fundamentals and analysis. Relative stability: gain margin and phase margin. Stability analysis using Bode plots. Need for compensators lead, lag and lead lag compensators, design of lead compensator using Bode plots.

### MODULE 5

**State Variable Analysis:** State variables, state equations, state variable representation of electrical and mechanical systems, dynamic equations. Transfer function from state variable representation, solution of state equations, state transition matrix. Concept of controllability and observability and techniques to test them – Kalman's Test.

### Text Books

1. Nise, N. S., Control Systems Engineering, 7/e, John Wiley & Sons (Wiley India Edition), 2015.
2. M. Gopal, Digital Control and State Variable Method, 4/e, McGraw Hill Education India, 2012.
3. Ogata K., Modern Control Engineering, Prentice Hall of India, 4/e, Pearson Education, 2014.

tion,2002

4. Salivahanan, S., Rengaraj, R., Venkatakrishnan, G.R., Control Systems Engineering, Pearson Education India, 1/e, 2015

5. Nagrath, I. J. and Gopal, M., Control Systems Engineering, 5/e, New Age International (P) Ltd., 2010.



## COURSE CONTENTS AND LECTURE SCHEDULE

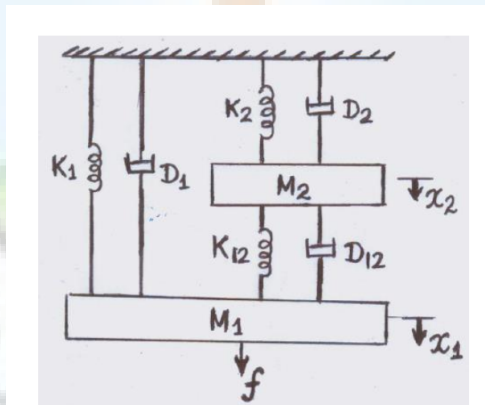
| No  | Topic                                                                        | No. of Lecture/- Tutorial Hours |
|-----|------------------------------------------------------------------------------|---------------------------------|
|     | <b>Module 1: Introduction to Control Systems</b>                             | <b>8</b>                        |
| 1.1 | Basic components of a control system – elements, examples, need for control. | 1                               |
| 1.2 | Open-loop and closed-loop systems – comparison and examples.                 | 1                               |
| 1.3 | Mathematical modeling of electrical and mechanical systems.                  | 2                               |
| 1.4 | Transfer function derivation – concept and properties.                       | 1                               |
| 1.5 | Block diagram representation and reduction techniques.                       | 1                               |
| 1.6 | Signal flow graph – Mason's Gain Formula.                                    | 1                               |
| 1.7 | Impulse response and its relation with transfer function of linear systems.  | 1                               |
|     | <b>Module 2: Time and Frequency Domain Analysis</b>                          | <b>9</b>                        |
| 2.1 | Standard test signals – step, ramp, parabolic and impulse.                   | 1                               |
| 2.2 | Time response of first-order systems.                                        | 1                               |
| 2.3 | Time response of second-order systems – step and ramp input.                 | 2                               |
| 2.4 | Time domain specifications – rise time, peak time, overshoot, settling time. | 2                               |
| 2.5 | Steady-state error and static error coefficients.                            | 2                               |
| 2.6 | Introduction to frequency domain specifications.                             | 1                               |
|     | <b>Module 3: Stability and Root Locus Techniques</b>                         | <b>9</b>                        |
| 3.1 | Concept of BIBO and absolute stability.                                      | 1                               |
| 3.2 | Routh-Hurwitz stability criterion.                                           | 2                               |
| 3.3 | Effect of P, PI and PID controllers on system response.                      | 2                               |
| 3.4 | Root locus concepts – properties and construction rules.                     | 2                               |
| 3.5 | Applications of root locus in system stability and performance.              | 1                               |
| 3.6 | Effect of addition of a zero and a pole.                                     | 1                               |
|     | <b>Module 4: Frequency Response and Compensator Design</b>                   | <b>9</b>                        |
| 4.1 | Nyquist stability criterion – fundamentals and analysis.                     | 3                               |
| 4.2 | Relative stability: gain margin and phase margin.                            | 1                               |
| 4.3 | Stability analysis using Bode plots.                                         | 2                               |
| 4.4 | Need for compensators – lead, lag, and lead-lag types.                       | 1                               |
| 4.5 | Design of lead compensator using Bode plots.                                 | 2                               |
|     | <b>Module 5: State Variable Analysis</b>                                     | <b>10</b>                       |
| 5.1 | Concept of state, state variables and state equations.                       | 1                               |

|     |                                                                  |                 |
|-----|------------------------------------------------------------------|-----------------|
| 5.2 | State-space representation of electrical and mechanical systems. | 4               |
| 5.3 | Derivation of transfer function from state model.                | 1               |
| 5.4 | Solution of state equations and state transition matrix.         | 2               |
| 5.5 | Concept of controllability and observability.                    | 1               |
| 5.6 | Testing of controllability and observability – Kalman's test.    | 1               |
|     | <b>Total Hours</b>                                               | <b>45 Hours</b> |

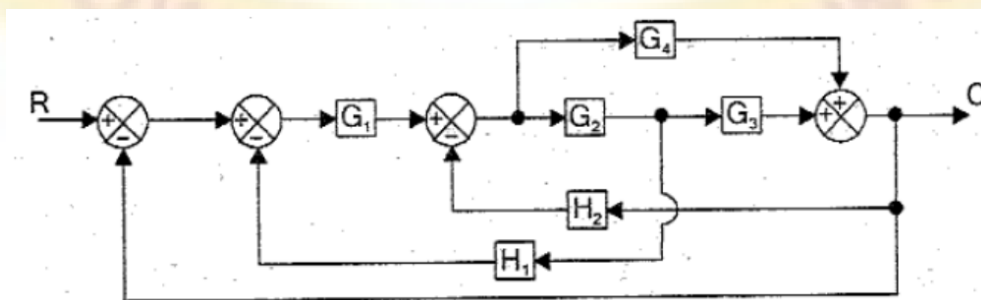
### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Write the differential equations governing the mechanical system shown in figure. Draw the force-voltage and force-current electrical analogous circuits and verify by writing mesh and node equations.



2. Obtain the transfer function of the system shown in figure using block diagram reduction rules.



#### Course Outcome 2 (CO 2):



1. Consider a unity feedback control system with the closed loop transfer functions given by  $\frac{C(s)}{R(s)} = \frac{Ks + b}{s^2 + as + b}$ . Determine the open loop transfer function. Show that the steady state error in the unit ramp input response is  $e_{ss} = \frac{a - k}{b}$ .
2. Derive the expressions for peak time and peak overshoot of an under damped second order system.

**Course Outcome 3 (CO 3):**

1. Sketch the root locus of the system whose open loop transfer function is  $G(s) = \frac{K}{s(s+2)(s+4)}$ . Find the value of K so that the damping ratio of the closed loop system is 0.5
2. The characteristic equation of a system is  $s^7 + 9s^6 + 24s^5 + 24s^4 + 24s^3 + 24s^2 + 23s + 15 = 0$ . Determine the location of roots on S- plane and hence comment on the stability of the system using Ruth Hurwitz criterion

**Course Outcome 4 (CO 4):**

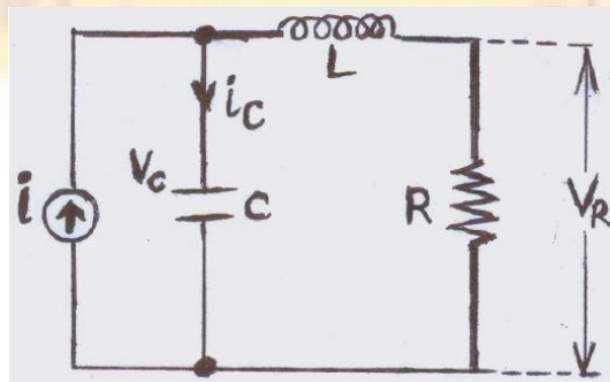
1. Determine the gain margin and phase margin of the system  $G(s) = \frac{10}{s(1 + 0.4s)(1 + 0.1s)}$  from the bode plot.
2. Draw the Nyquist plot for the system whose open loop transfer function is  $G(s)H(s) = \frac{K}{s(s+1)(s+5)}$ . Determine the range of K for which the closed loop system is stable.

**Course Outcome 5 (CO 5):**

1. Determine the transfer function of a system represented by

$$\dot{X} = \begin{bmatrix} -5 & 1 \\ 3 & 8 \end{bmatrix} X + \begin{bmatrix} 1 \\ 1 \end{bmatrix} U; \quad Y = \begin{bmatrix} 1 & 0 \end{bmatrix} U$$

2. Obtain the state model for the electrical network



MODEL QUESTION PAPER

QP CODE:

Pages: 5

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2026

**Course Code: B24EC3T02**

**Course Name: CONTROL SYSTEMS**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Describe the working of a closed loop control system with the help of a suitable block diagram.
2. Obtain the impulse response of a first order RC high pass filter.
3. Obtain the expression for time response of a first order system for step input and compute the steady state error.
4. Determine the parabolic error constant for the unity feedback control system  $G(s) = \frac{10}{(s+2)(s+1)s^2}$
5. What is the criterion on the roots of the characteristic equation for the stability? How is it connected to the BIBO stability?
6. State the angle and magnitude criteria that roots of the characteristic equation must be satisfied.
7. Draw the s-plane contour used for mapping, for stability analysis, to the plane of open-loop transfer function  $G(s)H(s) = \frac{1}{s(s+1)}$ . Explain the choice of the contour.
8. Write and explain the transfer function for a first order phase lag compensator. State the function of a phase lag compensator in a control system.
9. Give two advantages for using state variable representation of systems.

10. Find the state equation for the system represented by the differential equation

$$\frac{d^2y}{dt^2} + 20\frac{dy}{dt} + 100y = u(t)$$

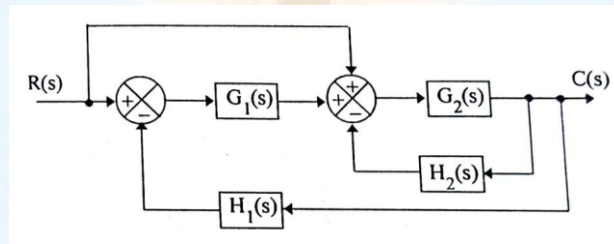
where,  $u(t)$  is the input and  $y(t)$  is the output. Take zero initial conditions.

### PART B

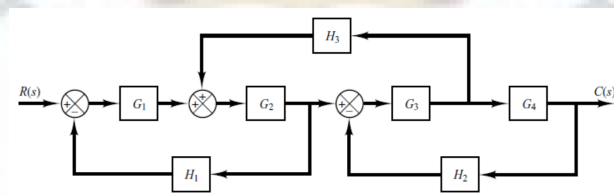
**Answer any one question from each module. Each question carries 14 marks**

#### Module I

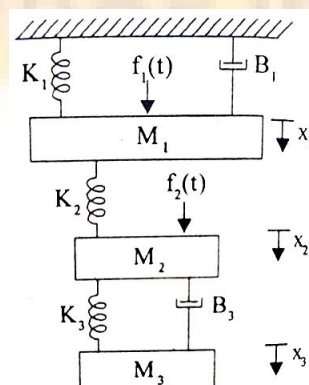
11. a) Draw the schematic of a second order spring-mass-damper (SMD) system and obtain its transfer function. Draw the Force current analogy circuit of the system. (5)
- b) Find the transfer function of the following block diagram using block diagram reduction technique. Verify the same using SFG and mason's gain formula (9)



12. a) Find the transfer function of the given system using block reduction technique. Verify the result using Mason's gain equation (7)



- b) Find the differential equation governing the mechanical system shown in fig. Draw the corresponding Force-Voltage analogous circuit (7)



**Module II**

13. a) Define position, velocity and acceleration error constants for a unity feedback control system. (7)
- b) For the second order system with complex poles on the left half of s-plane, derive the expression for rise time, settling time, and steady state error parameters. (7)
14. a) For a unity feedback system with  $G(s) = \frac{10}{s^2 + 14s + 50}$  find the steady state error values for unit step and unit ramp inputs (7)
- b) Open loop transfer function of a unity feedback system is  $G(s) = \frac{10}{s(s+5)(s+10)}$ . Determine the steady state error and error constants for the input  $r(t) = 5 + 10t + 6t^2$  (7)

**Module III**

15. a) Construct Routh array and determine the stability of the system represented by the characteristic equation  $s^6 + 2s^5 + s^4 + 2s^3 + s^2 + 2s + 1 = 0$ . Comment on the location of roots in s plane (7)
- b) Plot the locus of roots for the system having the following open loop transfer function.
- $$G(s) = \frac{K(s^2 + 4)}{s(s + 4)}$$
- (7)
16. a) Explain the effect of adding a pole to a second order system. (7)
- b) Write the general transfer functions of P, PI and PID controllers. Explain their role in a control system design (7)

**Module IV**

17. a) Draw the bode plots of a system whose open loop transfer function is given by (7)

$$G(s)H(s) = \frac{K}{s(s+1)(s+3)}$$

- b) State Cauchy's argument principle with the conditions to be applied on the contour of mapping. State the Nyquist criterion of stability on the open loop transfer function of a control system. (7)
18. a) Draw the Nyquist plot and check for stability of the system with open loop transfer function. (7)

$$G(s)H(s) = \frac{3}{s(s+1)(s+4)}$$

- b) The open loop transfer function of certain unity feedback control system is given by  $G(s) = \frac{K}{s(s+4)(s+80)}$ . It is desired to have the phase margin to be at least  $33^\circ$  and the velocity error constant  $K_v = 30$  per sec. Design a phase lead series compensator. (7)

**Module V**

19. a) Construct the state model for the system described by (7)

$$y'' + 7y' + 5y + 6 \int_0^t y \, dt = u' + 3u + 2 \int_0^t u \, dt$$

- b) Obtain the state model for the given transfer function (7)

$$\frac{Y(s)}{U(s)} = \frac{1}{s^2 + s + 1}$$

20. a) The transfer function of a control system is given by (7)

$$\frac{Y(s)}{U(s)} = \frac{s+2}{s^3 + 9s^2 + 26s + 4}$$

Check for controllability and observability.

- b) A linear time invariant system is described by the state equation (7)

$$\dot{X}(t) = \begin{bmatrix} -1 & 2 \\ -1 & -3 \end{bmatrix} X(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} r(t)$$

Find the state transition matrix. If the initial state vector is  $X(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$ , obtain the zero input response.

| <b>B24EC3T03</b> | <b>ANALOG AND<br/>DIGITAL COM-<br/>MUNICATION</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF<br/>INTRODUCTION</b> |
|------------------|---------------------------------------------------|----------|----------|----------|----------|---------------|---------------------------------|
|                  |                                                   | 3        | 1        | 0        | 5        |               |                                 |

**Preamble**

This course aims to develop analog and digital communication systems.

**Prerequisites**

B24EC2T05: Signals and Systems

B24MA2T04A: Stochastic Processes and Numerical Methods

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                     |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Explain the existent analog communication systems and understand the fundamental ideas of noises.                                                                   |
| <b>CO 2</b> | Apply the concept of random processes to LTI systems                                                                                                                |
| <b>CO 3</b> | Apply waveform coding techniques in digital transmission                                                                                                            |
| <b>CO 4</b> | Understand signal space concepts and equalization techniques to analyze and design reliable baseband digital communication systems in the presence of noise and ISI |
| <b>CO 5</b> | Identify various digital modulation techniques in signal transmission                                                                                               |

**Mapping of Course Outcomes With Program Outcomes**

|             | <b>PO 1</b> | <b>PO 2</b> | <b>PO 3</b> | <b>PO 4</b> | <b>PO 5</b> | <b>PO 6</b> | <b>PO 7</b> | <b>PO 8</b> | <b>PO 9</b> | <b>PO 10</b> | <b>PO 11</b> |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|
| <b>CO 1</b> | 3           | 3           | 2           | 1           | 2           | 1           |             |             |             |              | 3            |
| <b>CO 2</b> | 3           | 3           | 2           | 2           | 2           | 1           |             |             |             |              | 3            |
| <b>CO 3</b> | 3           | 3           | 3           | 1           | 2           | 1           |             |             |             |              | 3            |
| <b>CO 4</b> | 3           | 3           | 3           | 3           | 2           | 1           |             |             |             |              | 3            |
| <b>CO 5</b> | 3           | 3           | 3           | 2           | 2           | 1           |             |             |             |              | 3            |

**Assessment Pattern****Mark Distribution**



| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## **SYLLABUS**

### **MODULE 1**

Block diagram of a communication system. Need for analog modulation. Amplitude modulation. Equation and spectrum of AM signal. DSB-SC and SSB systems. Frequency and phase modulation. Spectrum of FM signal, Narrow and wide band FM and their spectra. FM transmitter and receiver. Noise models in communication systems: Types of noise (thermal, shot, etc.) Signal-to-noise ratio (SNR)

### **MODULE 2**

Review of random variables – both discrete and continuous. CDF and PDF, statistical averages. (Only definitions, computations and significance). Stochastic processes, Stationarity. Conditions for WSS and SSS. Autocorrelation and power spectral density. LTI systems with WSS as input.

### **MODULE 3**

Source coding theorems (Statements only). Waveform coding. Sampling and Quantization. Pulse code modulation, Transmitter and receiver. Companding. A and mu-law companders. DPCM transmitter and receiver. Design of linear predictor. Wiener-Hopf equation. Delta modulation. Slope overload. Line codes, Power Spectral Density of Unipolar / Polar RZ & NRZ — Bipolar NRZ — Manchester.

### **MODULE 4**

Gram-Schmitt procedure. Signal space. Baseband transmission through AWGN channel. Mathematical model of ISI. Nyquist criterion for zero ISI. Signal modeling for ISI, Raised cosine and Square-root raised cosine spectrum, Eye Pattern, Partial response signalling and duobinary coding. Equalization. Design of zero forcing equalizer. Vector model of AWGN channel. Matched filter and correlation receivers. MAP receiver, Maximum likelihood receiver and probability of error.

### **MODULE 5**

Digital modulation schemes. Baseband BPSK system and the signal constellation. BPSK transmitter and receiver. Base band QPSK system and Signal constellations. Plots of BER Vs SNR with analysis. QPSK transmitter and receiver. Quadrature amplitude modulation and signal constellation.

**Text Books**

1. Communication Systems, Simon Haykin, Wiley
2. Digital Communications: Fundamentals and Applications, Sklar, Pearson
3. Digital Telephony, John C. Bellamy, Wiley
4. Principles of Digital Communication, R. Gallager, Oxford University Press
5. Digital Communication, John G Proakis, Wiley



**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                                                                                                                                                                                                                | No of Lecture/Tutorial Hours |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                                                                                                                      | <b>8</b>                     |
| 1.1 | Block diagram of a communication system. Need for analog modulation.                                                                                                                                                                                 | 2                            |
| 1.2 | Amplitude modulation. Equation and spectrum of AM signal.                                                                                                                                                                                            | 1                            |
| 1.3 | DSB-SC and SSB systems.                                                                                                                                                                                                                              | 1                            |
| 1.4 | Frequency and phase modulation. Spectrum of FM signal, Narrow and wide band FM and their spectra.                                                                                                                                                    | 2                            |
| 1.5 | FM transmitter and receiver.                                                                                                                                                                                                                         | 1                            |
| 1.6 | Noise models in communication systems: Types of noise (thermal, shot, etc.) Signal-to-noise ratio (SNR)                                                                                                                                              | 1                            |
|     | <b>Module 2</b>                                                                                                                                                                                                                                      | <b>8</b>                     |
| 2.1 | Review of random variables – both discrete and continuous. CDF and PDF, statistical averages. (Only definitions, computations and significance).                                                                                                     | 3                            |
| 2.2 | Stochastic processes, Stationarity.                                                                                                                                                                                                                  | 2                            |
| 2.3 | Conditions for WSS and SSS. Autocorrelation and power spectral density. LTI systems with WSS as input.                                                                                                                                               | 3                            |
|     | <b>Module 3</b>                                                                                                                                                                                                                                      | <b>12</b>                    |
| 3.1 | Waveform coding. Sampling and Quantization.                                                                                                                                                                                                          | 2                            |
| 3.2 | Pulse code modulation, Transmitter and receiver. Companding. A and mu-law companders.                                                                                                                                                                | 4                            |
| 3.3 | DPCM transmitter and receiver. Design of linear predictor. Wiener-Hopf equation.                                                                                                                                                                     | 3                            |
| 3.4 | Delta modulation. Slope overload.                                                                                                                                                                                                                    | 1                            |
| 3.5 | Line codes, Power Spectral Density of Unipolar / Polar RZ & NRZ — Bipolar NRZ — Manchester.                                                                                                                                                          | 2                            |
|     | <b>Module 4</b>                                                                                                                                                                                                                                      | <b>13</b>                    |
| 4.1 | Gram-Schmitt procedure. Signal space.                                                                                                                                                                                                                | 2                            |
| 4.2 | Baseband transmission through AWGN channel. Mathematical model of ISI. Nyquist criterion for zero ISI. Signal modeling for ISI, Raised cosine and Square-root raised cosine spectrum, Eye Pattern, Partial response signalling and duobinary coding. | 4                            |
| 4.3 | Equalization. Design of zero forcing equalizer.                                                                                                                                                                                                      | 2                            |
| 4.4 | Vector model of AWGN channel. Matched filter and correlation receivers                                                                                                                                                                               | 3                            |
| 4.5 | MAP receiver, Maximum likelihood receiver and probability of error.                                                                                                                                                                                  | 2                            |
|     | <b>Module 5</b>                                                                                                                                                                                                                                      | <b>7</b>                     |

|     |                                                                                                                    |                 |
|-----|--------------------------------------------------------------------------------------------------------------------|-----------------|
| 5.1 | Digital modulation schemes                                                                                         | 1               |
| 5.2 | Baseband BPSK system and the signal constellation. BPSK transmitter and receiver.                                  | 2               |
| 5.3 | Base band QPSK system and Signal constellations. Plots of BER Vs SNR with analysis. QPSK transmitter and receiver. | 3               |
| 5.4 | Quadrature amplitude modulation and signal constellation.                                                          | 1               |
|     | <b>Total Hours</b>                                                                                                 | <b>49 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. What are the needs for analog modulation.
2. Give mathematical model of FM signal and explain its spectrum.

#### Course Outcome 2 (CO 2):

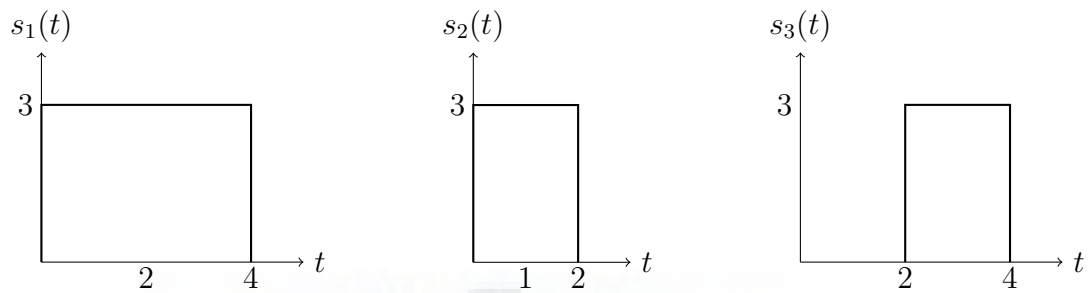
1. What is the difference between a discrete and a continuous random variable.
2. Consider a random process  $X(t) = \cos(t + A)$ , where  $A$  is a random variable that is uniformly distributed over the interval  $[0, 2\pi]$ . Determine whether  $X(t)$  is wide-sense stationary or not.

#### Course Outcome 3 (CO 3):

1. Compute the A and mu law quantized values of a signal that is normalized to 0.8 with  $A=32$  and  $\mu=255$ .
2. A delta modulator with a fixed step size of 0.75 V, is given a sinusoidal message signal. If the sampling frequency is 30 times the Nyquist rate, determine the maximum permissible amplitude of the message signal if slope overload is to be avoided.

#### Course Outcome 4 (CO 4):

1. Apply Gram-Schmidt orthogonalization to obtain orthonormal basis functions for the signals shown below. Express the signals in terms of orthonormal basis functions.



2. Derive the Nyquist Criterion for zero ISI

**Course Outcome 5 (CO 5):**

1. Draw the BER v/s SNR plot for the BPSK system and explain the graph.
2. Give the mathematical model of a QPSK signal and plot its signal constellation.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24EC3T03**

**Course Name: ANALOG AND DIGITAL COMMUNICATION**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Discuss the need for modulation in communication system.
2. A 105 MHz carrier signal is frequency modulated by 7 kHz sine wave. The resultant signal has a frequency deviation of 50 kHz. Determine the modulation index and bandwidth of FM wave.
3. In a game a six faced die is thrown. If 1 or 2 comes the player gets Rs 30, if 3 or 4 the player gets Rs 10, if 5 comes, he loses Rs. 30 and in the event of 6, he loses Rs. 100. Plot the CDF and PDF of gain or loss.
4. What are the conditions for a stochastic process to be wide sense stationary?
5. Compute the step size for a delta modulator without slope overload if the input signal is  $x(t) = A \cos(2\pi \times 120t)$ .
6. Discuss the need of regenerative repeater in PCM system.
7. Give the mathematical model of ISI
8. What is meant by equalization and why is it needed?
9. Draw the signal constellation of a QPSK system with and without AWGN.
10. What are the advantages of QPSK over BPSK?

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Give the model of AM signal and plot its spectrum (10)  
b) If a sinusoidal is amplitude modulated by the carrier  $5\cos 2\pi \times 300t$  to a depth of 30 %, compute the power in the resultant AM signal. (4)
12. a) Explain how SSB is transmitted and received. (10)  
b) Compute the bandwidth of the narrowband FM signal with modulating signal frequency of 1kHz and index of modulation 0.3 (4)

**Module II**

13. a) Consider a random process  $X(t) = \cos(t + A)$  where A is a random variable that is uniformly distributed over the interval  $[0, 2\pi]$ . Find whether X(t) is wide-sense stationary or not. (10)  
b) Give the relation between autocorrelation and power spectral density of a WSS. (4)
14. a) State and explain the properties of the autocorrelation function. (6)  
b) Find the autocorrelation function of a sinusoidal process with random phase  $X(t) = A \cos(2\pi f_c t + \theta)$  (8)

**Module III**

15. a) Describe the delta modulation system with a neat block diagram. Also, illustrate the quantization error in delta modulation. (8)  
b) A delta modulator with a fixed step size of 0.75 V, is given a sinusoidal message signal. If the sampling frequency is 30 times the Nyquist rate, determine the maximum permissible amplitude of the message signal if slope overload is to be avoided. (6)
16. a) Consider a random process  $X(t) = \cos(t + A)$  where A is a random variable that is uniformly distributed over the interval  $[0, 2\pi]$ . Find whether X(t) is wide-sense stationary or not. (7)  
b) State and explain the sampling theorem. A PCM system uses a uniform quantizer followed by an 8-bit encoder. If the bit rate of the system is  $10^8$  bps, then what is the maximum bandwidth of the lowpass message signal for which the system operates satisfactorily? (7)

**Module IV**

17. a) Find an orthonormal basis set for the following set of signals:

$$\begin{aligned}s_1(t) &= A \sin(2\pi f_0 t), \quad 0 \leq t \leq T, \\ s_2(t) &= A \cos(2\pi f_0 t), \quad 0 \leq t \leq T,\end{aligned}$$

where  $f_0 = \frac{m}{T}$  and  $m$  is an integer. (7)

- b) Plot the above signal constellation and draw the decision region on it. Compute the probability of error. (7)

18. a) What are the practical difficulties encountered in an ideal Nyquist channel? How can those be overcome by raised cosine filters? (8)

- b) Compare Maximum Likelihood receiver and MAP receiver. (6)

### Module V

19. For a shift keying system defined by  $s(t) = A_c \sin(2\pi f_c t) \pm A_m \cos(2\pi f_c t)$ , plot the signal constellation. Compute the probability of error. (14)

20. Draw the block diagram of BPSK generation and detection system. Explain with relevant equations. (14)

| B24EC3T04 | VLSI DESIGN | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|-------------|---|---|---|---|--------|----------------------|
|           |             | 3 | 1 | 0 | 5 | 4      | 2024                 |

### Preamble

This course provides a comprehensive understanding of semiconductor fabrication processes and VLSI design methodologies. It enables students to design and analyze digital VLSI circuits from device fabrication to system-level implementation.

### Prerequisites

B24EC2T04 SOLID STATE DEVICES  
 B24EC2T03 ANALOG CIRCUITS 2  
 B24EC1T03 LOGIC CIRCUIT DESIGN

### Course Outcomes

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                                      |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Explain the semiconductor fabrication process including material preparation, oxidation, diffusion, ion implantation, epitaxy, and lithography used in IC manufacturing.[Understand] |
| <b>CO 2</b> | Compare various VLSI design methodologies such as full-custom, standard-cell, gate-array, SoC, and FPGA, and analyze their speed, power, and area trade-offs.[Understand, Analyze]   |
| <b>CO 3</b> | Design and analyze static CMOS and MOSFET logic circuits, and draw corresponding stick diagrams and layouts following CMOS design rules.[Understand, Apply]                          |
| <b>CO 4</b> | Explain the design and operation of different memory cells and programmable logic devices including ROM, SRAM, DRAM, PLAs, and FPGAs.[Understand, Apply]                             |
| <b>CO 5</b> | Design basic arithmetic circuits such as adders and multipliers, and evaluate their performance in terms of speed and area.[Analyze, Apply]                                          |

### Mapping of Course Outcomes With Program Outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 2    | 1    |      | 2    | 2    | 2    |      |      |       | 2     |
| <b>CO 2</b> | 3    | 3    |      | 2    |      | 2    | 2    |      | 1    |       | 2     |
| <b>CO 3</b> | 3    | 2    | 3    | 2    | 3    | 1    | 1    | 2    | 1    | 1     | 2     |
| <b>CO 4</b> | 3    | 2    | 2    |      | 3    |      |      |      |      |       | 2     |
| <b>CO 5</b> | 3    | 3    | 3    | 2    | 3    |      |      |      |      |       | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         |                       |                 |                                    |
| Understand       | 80                    | 80              | 80                                 |
| Apply            |                       | 20              | 10                                 |
| Analyse          | 20                    |                 | 10                                 |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Fabrication Techniques:** Crystal growth CZ process, wafer preparation, Thermal Oxidation, Dry and Wet oxidation, Deal Grove model, Diffusion- Fick's Laws, diffusion techniques. Ion implantation-Technique, annealing, Epitaxy, Lithography- Photo lithographic sequence, Electron Beam Lithography, Etching and metal deposition, N-well CMOS IC Fabrication Sequence.

### MODULE 2

**VLSI Design Methodologies :** Introduction: Moore's law .ASIC design, Full custom ASICs, Standard cell based ASICs, Gate array based ASICs, SoCs, FPGA devices, ASIC and FPGA Design flows, Top-Down and Bottom-Up design methodologies. Logical and Physical design. Speed power and area considerations in VLSI design

### MODULE 3

**Static CMOS Logic Design :** CMOS inverters- DC characteristics, switching characteristics, power dissipation MOSFET Logic Design -Pass transistor logic, Complementary pass transistor logic and transmission gate logic , realization of functions Layout Design rules-Stick Diagram and layout of CMOS Inverter, two input NAND and NOR gates

### MODULE 4

**Storage Cells :** Read Only Memory-4x4 MOS ROM Cell Arrays(OR,NOR,NAND), Random Access Memory –SRAM-Six transistor CMOS SRAM cell, DRAM –Three transistor and One transistor Dynamic Memory Cell Introduction to PLDs and FPGAs, Design of PLAs.

### MODULE 5

**Arithmetic Circuits :** Adders: Static adder, Carry-Bypass adder, Linear Carry- Select adder, Square- root carry- select adder. Multipliers: Array multiplier.

#### Text Books

1. Sung –Mo Kang & Yusuf Leblebici, CMOS Digital Integrated Circuits- Analysis & Design, McGraw-Hill, Third Ed., 2003.
2. S.M. SZE, VLSI Technology, 2/e, Indian Edition, McGraw-Hill,2003
3. Neil H.E. Weste, Kamran Eshraghian, Principles of CMOS VLSI Design- A Systems Perspective, Second Edition. Pearson Publication, 2005.
4. John P Uyemura, Introduction to VLSI Circuits and Systems, Wiley India, 2006



5. Jan M.Rabaey, Digital Integrated Circuits- A Design Perspective, Prentice Hall, Second Edition, 2005.
6. Razavi - Design of Analog CMOS Integrated Circuits,1e, McGraw Hill Education India Education,New Delhi 2003

### **COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                                           | <b>No of Lecture/Tutorial Hours</b> |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                                                        | <b>14</b>                           |
| 1.1       | Material Preparation- Crystal growth -CZ process, wafer preparation                                                                    | 2                                   |
| 1.2       | Thermal Oxidation- Growth mechanisms, Dry and Wet oxidation.                                                                           | 2                                   |
| 1.3       | Diffusion- Fick's Laws, diffusion techniques.                                                                                          | 2                                   |
| 1.4       | Ion implantation-Technique, annealing, Epitaxy.                                                                                        | 2                                   |
| 1.5       | Lithography- Photo lithographic sequence, Electron Beam Lithography, Etching and metal deposition                                      | 2                                   |
| 1.6       | N-well CMOS IC Fabrication Sequence.                                                                                                   | 4                                   |
|           | <b>Module 2</b>                                                                                                                        | <b>7</b>                            |
| 2.1       | Introduction: Moore's law .ASIC design, Full custom ASICs,                                                                             | 2                                   |
| 2.2       | Standard cell based ASICs, Gate array based ASICs, SoCs                                                                                | 2                                   |
| 2.3       | FPGA devices, ASIC and FPGA Design flows, Top-Down and Bottom-Up design methodologies.                                                 | 1                                   |
| 2.4       | Logical and Physical design. Speed power and area considerations in VLSI design                                                        | 2                                   |
|           | <b>Module 3</b>                                                                                                                        | <b>11</b>                           |
| 3.1       | CMOS inverter                                                                                                                          | 1                                   |
| 3.1       | DC characteristics,                                                                                                                    | 2                                   |
| 3.3       | Switching characteristics, power dissipation                                                                                           | 3                                   |
| 3.4       | MOSFET Logic Design -Pass transistor logic, Complementary pass transistor logic and transmission gate logic, Realization of functions, | 3                                   |
| 3.5       | Layout Design rules-Stick Diagram                                                                                                      | 2                                   |
| 3.6       | Layout of CMOS Inverter, two input NAND and NOR gates.                                                                                 | 1                                   |
|           | <b>Module 4</b>                                                                                                                        | <b>7</b>                            |
| 4.1       | Read Only Memory-4x4 MOS ROM Cell Arrays(OR,NOR,NAND),                                                                                 | 2                                   |
| 4.2       | Random Access Memory –SRAM-Six transistor CMOS SRAM cell                                                                               | 1                                   |

|     |                                                               |                 |
|-----|---------------------------------------------------------------|-----------------|
| 4.3 | DRAM –Three transistor and One transistor Dynamic Memory Cell | 1               |
| 4.4 | Introduction to PLDs and FPGAs                                | 2               |
| 4.5 | Design of PLAs.                                               | 1               |
|     | <b>Module 5</b>                                               | <b>5</b>        |
| 5.1 | Adders: Static adder                                          | 1               |
| 5.2 | Carry-Bypass adder, Linear Carry- Select adder                | 2               |
| 5.3 | Square- root carry- select adder                              | 1               |
| 5.4 | Multipliers: Array multiplier                                 | 1               |
|     | <b>Total Hours</b>                                            | <b>44 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the steps involved in the fabrication of a CMOS transistor
2. Compare CZ and FZ crystal growth techniques.
3. Derive Deal-Grove model for thermal oxidation.
4. Discuss ion implantation and annealing process.

#### Course Outcome 2 (CO 2):

1. Compare Full-custom and Standard-cell-based ASIC design flows.
2. Explain FPGA architecture and its advantages.
3. Analyze trade-offs between speed, power, and area in VLSI design.

#### Course Outcome 3 (CO 3):

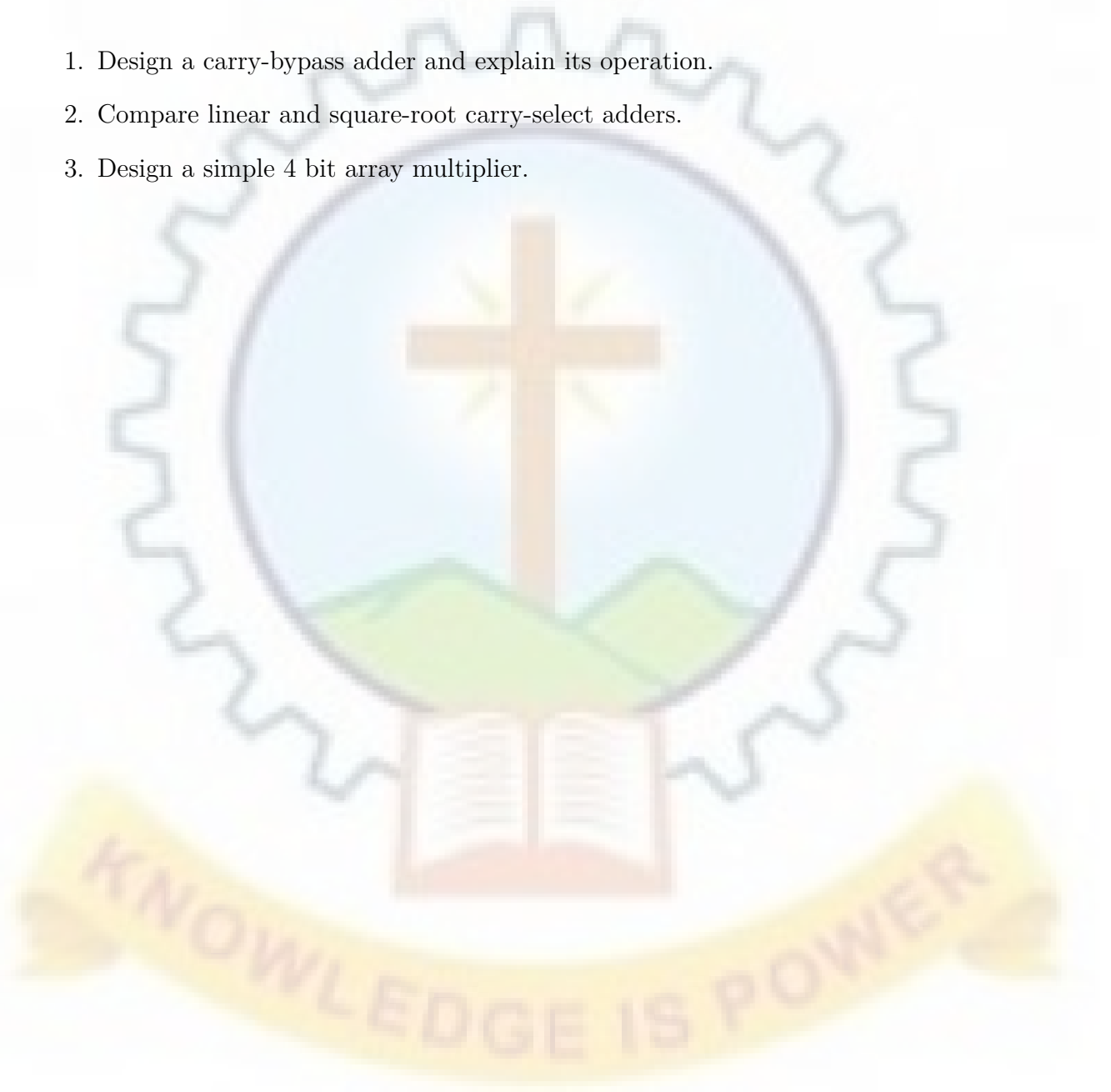
1. Draw the DC transfer characteristics of a CMOS inverter.
2. Design a two-input NAND gate using CMOS logic and draw the stick diagram.
3. Explain transmission gate logic with circuit diagrams.

#### Course Outcome 4 (CO 4):

1. Explain the working of 6T CMOS SRAM cell with circuit diagram.
2. Differentiate between SRAM and DRAM.
3. Explain the design of 4x4 MOS ROM Cell Arrays.

**Course Outcome 5 (CO 5):**

1. Design a carry-bypass adder and explain its operation.
2. Compare linear and square-root carry-select adders.
3. Design a simple 4 bit array multiplier.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24EC3T04**

**Course Name: VLSI DESIGN**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Explain the Czochralski (CZ) crystal growth techniques.
2. Explain the Deal-Grove model of thermal oxidation.
3. Differentiate between diffusion and ion implantation.
4. What is epitaxy? Mention its importance in IC fabrication.
5. Explain the role of lithography in IC manufacturing.
6. Define ASIC and FPGA. List one major difference between them.
7. Draw the DC characteristics of a CMOS inverter.
8. Explain the working principle of a 6T CMOS SRAM cell.
9. Compare SRAM and DRAM based on structure and operation.
10. Write short notes on carry-select adders.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain the steps involved in the fabrication of an integrated circuit starting from material preparation to metallization. (7)  
b) Derive the Deal-Grove model for thermal oxidation and explain its practical relevance. (7)
12. a) Describe diffusion and ion implantation processes used in IC fabrication. (7)  
b) Explain lithography, etching, and metal deposition techniques with neat diagrams. (7)

**Module II**

13. a) Explain the different types of ASICs with neat block diagrams. (7)  
b) Discuss FPGA-based design methodology and its advantages. (7)
14. a) Compare top-down and bottom-up design methodologies in VLSI design. (7)  
b) Discuss speed, power, and area trade-offs in VLSI design. (7)

**Module III**

15. a) Draw and explain the DC and switching characteristics of a CMOS inverter. (7)  
b) Design and draw the stick diagrams of a two-input NAND and NOR gate using CMOS logic. (7)
16. a) Explain pass transistor logic and transmission gate logic with examples. (7)  
b) State and explain the layout design rules used in CMOS circuits. (7)

**Module IV**

17. a) Explain the working of ROM cell arrays (OR, NOR, NAND types) with diagrams. (7)  
b) Describe the operation of a six-transistor CMOS SRAM cell. (7)
18. a) Explain the working of DRAM cells (1T and 3T types) with schematic diagrams. (7)  
b) Write short notes on PLAs and FPGAs with neat block diagrams. (7)

**Module V**

19. a) Explain the working of a carry-bypass adder and derive its delay expression. (7)  
b) Discuss the design and operation of a linear carry-select adder. (7)
20. a) Explain the structure and working of a square-root carry-select adder. (7)  
b) Describe the architecture and operation of an array multiplier. (7)

| B24EC3T05 | EMBEDDED SYSTEMS | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|------------------|---|---|---|---|--------|----------------------|
|           |                  | 2 | 1 | 0 | 4 |        |                      |

**Preamble**

This course aims to enable the students to design & implement simple embedded systems and lay the foundation to develop more complex embedded systems using ARM processors and Real-Time Operating Systems.

**Prerequisites**

B24ES1T01A : PROBLEM SOLVING AND PROGRAMMING TECHNIQUES

B24EC1T03 : LOGIC CIRCUIT DESIGN

B24EC1T04 : ANALOG CIRCUITS 1

B24EC2T02 : COMPUTER ARCHITECTURE AND MICROCONTROLLERS

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                               |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Discuss embedded system design process and identify the software and hardware components required for an embedded system. [Understand, Apply] |
| <b>CO 2</b> | Design and develop the hardware and software for simple embedded systems using 8051 microcontroller. [Apply, Create]                          |
| <b>CO 3</b> | Explain different communication standards inside an embedded system and how the memory & I/O devices are handled. [Understand]                |
| <b>CO 4</b> | Discuss the ARM processor architecture and develop embedded systems using STM32 microcontroller. [Apply, Create]                              |
| <b>CO 5</b> | Explain the basics of Real-Time Operating Systems and their use in embedded systems. [Understand]                                             |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 2    | 1    |      | 1    |      |      |      |      |       | 1     |
| <b>CO 2</b> | 3    | 3    | 3    | 2    | 3    | 1    |      | 2    | 2    | 2     | 2     |
| <b>CO 3</b> | 3    | 2    | 1    |      | 1    |      |      |      |      |       | 1     |
| <b>CO 4</b> | 3    | 3    | 3    | 2    | 3    | 1    |      | 2    | 2    | 2     | 2     |
| <b>CO 5</b> | 3    | 2    | 2    |      | 1    |      |      |      |      |       | 2     |



### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         |                       |                    |                                       |
| Understand       | 30                    | 30                 | 30                                    |
| Apply            | 40                    | 40                 | 40                                    |
| Analyse          | 20                    | 20                 | 20                                    |
| Evaluate         |                       |                    |                                       |
| Create           | 10                    | 10                 | 10                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have a maximum of 2 subdivisions.

## SYLLABUS

### MODULE 1

**Introduction to embedded systems:** Characteristics of an embedded system, components of embedded system hardware, embedded processors, System-on-Chip.

Embedded software development tools: Integrated Development Environment, cross compiler, creation of ROM image, simulators, emulators, ICE.

Embedded Product Development Lifecycle: Waterfall Model - Iterative Waterfall Model.

### MODULE 2

**Development of simple embedded systems:** Microcontroller interfacing: Interfacing 8051 microcontroller with various input/output devices and programs in C – Matrix keyboard, DS12887 Real Time Clock, DC motor speed control using PWM. Interfacing with ADC0804 and DAC0808 chips - waveform generation.

Embedded system design: Design of simple embedded systems for automatic plant watering system and intruder detection. Design and implement micro-projects using the 8051 microcontroller.

### MODULE 3

**Embedded system memory and peripherals:** Memory devices and systems: ROM-Flash, EEPROM, RAM-SRAM, DRAM, cache memory, memory mapping and addresses.

Communication devices: Serial communication standards and devices - UART, HDLC and SPI. Serial Bus Protocols -  $I^2C$  Bus, CAN Bus and USB Bus.

I/O device handling: Interrupts-Interrupt sources, ISR – Device drivers for handling ISR, Direct Memory Access.

### MODULE 4

**ARM processor-based systems:** ARM Simplified Block Diagram, ARM processor architecture - General Purpose Registers and Special Function Registers in ARM, RISC Architecture in ARM, 3-stage and 5-stage pipelining in ARM.

Developing ARM-based embedded systems: ARM STM32 microcontroller, Programming STM32 microcontroller using STM32CubeIDE. Interfacing STM32 microcontroller with I/O devices - LED, switches and LCD. Using peripherals in STM32 - Timers, ADC, and DAC. UART communication using STM32 (All programs in Embedded C). Design and implement micro-projects using STM32 microcontroller.

## **MODULE 5**

**Operating Systems and RTOS:** Functions performed by an OS, kernel, tasks/processes, threads, Inter Process Communication methods, semaphores, device drivers.

Real-Time Operating Systems: Real-time tasks - hard, soft and firm real-time tasks, features of an RTOS, Real-time scheduling algorithms, off-line and online scheduling, Rate Monotonic algorithm, Earliest Deadline First algorithm.

### **Text Books**

1. Raj Kamal, Embedded Systems Architecture, Programming and Design, Second Edition, TMH, 2008
2. Lyla B. Das, Embedded Systems: An Integrated Approach, 1/e, Lyla B. Das, Embedded Systems, 2012
3. Muhammad Ali Mazidi, Sarmad Naimi, Sepehr Naimi, Janice Mazidi, ARM assembly language programming & architecture. MicrodigitalEd, 2016
4. Muhammed Ali Mazidi, Gillispie Mazidi, Rolin D Mc Kinlay, The 8051 Microcontroller and Embedded Systems Using Assembly and C, Second Edition, 2008, Pearson Education
5. [https://wiki.st.com/stm32mcu/wiki/Main\\_Page](https://wiki.st.com/stm32mcu/wiki/Main_Page)
6. STM32CubeIDE user guide, STMicroelectronics

### **Reference Books**

1. Wayne Wolf, Computers as Components: Principles of Embedded Computing System Design, Morgan Kaufman Publishers - Elsevier 3ed, 2008
2. Steve Heath, Embedded Systems Design, Newnes – Elsevier 2ed, 2002
3. Steve Furber, ARM system-on-chip architecture, Addison Wesley, Second Edition, 2000
4. Andrew N. Sloss, Dominic Symes, Chris Wright, ARM System Developer's Guide Designing and Optimizing System Software, Morgan Kaufmann Publishers 2004
5. Tammy Noergaard, Embedded Systems Architecture, A Comprehensive Guide for Engineers and Programmers, Newnes – Elsevier 2ed, 2012
6. K.V. Shibu, Introduction to Embedded Systems, 2e, McGraw Hill Education India, 2016

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                                                                                                                                                                                            | No of Lecture/Tutorial Hours |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                                                                                                  | <b>6</b>                     |
| 1.1 | Characteristics of an embedded system.                                                                                                                                                                                           | 1                            |
| 1.2 | Components of embedded system hardware, embedded processors, System-on-Chip.                                                                                                                                                     | 2                            |
| 1.3 | Embedded software development tools: Integrated Development Environment, cross compiler, creation of ROM image, simulators, emulators, ICE.                                                                                      | 2                            |
| 1.4 | Embedded Product Development Lifecycle - Waterfall Model - Iterative Waterfall Model.                                                                                                                                            | 1                            |
|     | <b>Module 2</b>                                                                                                                                                                                                                  | <b>7</b>                     |
| 2.1 | 8051 microcontroller interfacing, Matrix keyboard.                                                                                                                                                                               | 2                            |
| 2.2 | DS12887 Real Time Clock, DC motor speed control using PWM                                                                                                                                                                        | 2                            |
| 2.3 | Interfacing with ADC0804 and DAC0808 chips - waveform generation.                                                                                                                                                                | 2                            |
| 2.4 | Embedded system design: Design of simple embedded systems for automatic plant watering system and intruder detection.                                                                                                            | 1                            |
| 2.5 | Design and implement micro-projects using the 8051 microcontroller.                                                                                                                                                              | 0                            |
|     | <b>Module 3</b>                                                                                                                                                                                                                  | <b>7</b>                     |
| 3.1 | Memory devices and systems: ROM-Flash, EEPROM, RAM-SRAM, DRAM, cache memory, Memory mapping and addresses.                                                                                                                       | 2                            |
| 3.2 | Communication devices: Serial communication standards and devices - UART, HDLC and SPI.                                                                                                                                          | 1                            |
| 3.3 | Serial Bus Protocols - I2C Bus, CAN Bus and USB Bus.                                                                                                                                                                             | 2                            |
| 3.4 | I/O device handling: Interrupts-Interrupt sources, ISR – Device drivers for handling ISR, Direct Memory Access.                                                                                                                  | 2                            |
|     | <b>Module 4</b>                                                                                                                                                                                                                  | <b>9</b>                     |
| 4.1 | ARM Simplified Block Diagram, ARM processor architecture - General Purpose Registers and Special Function Registers in ARM                                                                                                       | 1                            |
| 4.2 | RISC Architecture in ARM, 3-stage and 5-stage pipelining in ARM.                                                                                                                                                                 | 1                            |
| 4.3 | Developing ARM-based embedded systems: ARM STM32 microcontroller, Programming STM32 microcontroller using STM32CubeIDE. Interfacing STM32 microcontroller with I/O devices - LED, switches and LCD (All programs in Embedded C). | 3                            |

|     |                                                                                                                               |                 |
|-----|-------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 4.4 | Using peripherals in STM32 - Timers, ADC, and DAC. UART communication using STM32 (All programs in Embedded C).               | 4               |
| 4.5 | Design and implement micro-projects using STM32 micro-controller.                                                             | 0               |
|     | <b>Module 5</b>                                                                                                               | <b>7</b>        |
| 5.1 | Operating Systems and RTOS: Functions performed by an OS, kernel, tasks/processes, threads.                                   | 2               |
| 5.2 | Inter Process Communication methods, semaphores, device drivers.                                                              | 2               |
| 5.3 | Real-Time Operating Systems: Real-time tasks - hard, soft and firm real-time tasks, features of an RTOS.                      | 1               |
| 5.4 | Real-time scheduling algorithms, off-line and online scheduling, Rate Monotonic algorithm, Earliest Deadline First algorithm. | 2               |
|     | <b>Total Hours</b>                                                                                                            | <b>36 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Justify the need for sensors and actuators in an embedded system.
2. Explain various embedded software development and debugging tools.

#### Course Outcome 2 (CO 2):

1. Design a circuit using an 8051 microcontroller to generate a triangular waveform of amplitude 4V and write the C program for the same.
2. Design a circuit using an 8051 microcontroller and write a C program to operate a DC motor at two different speeds such that one speed is twice that of the other.

#### Course Outcome 3 (CO 3):

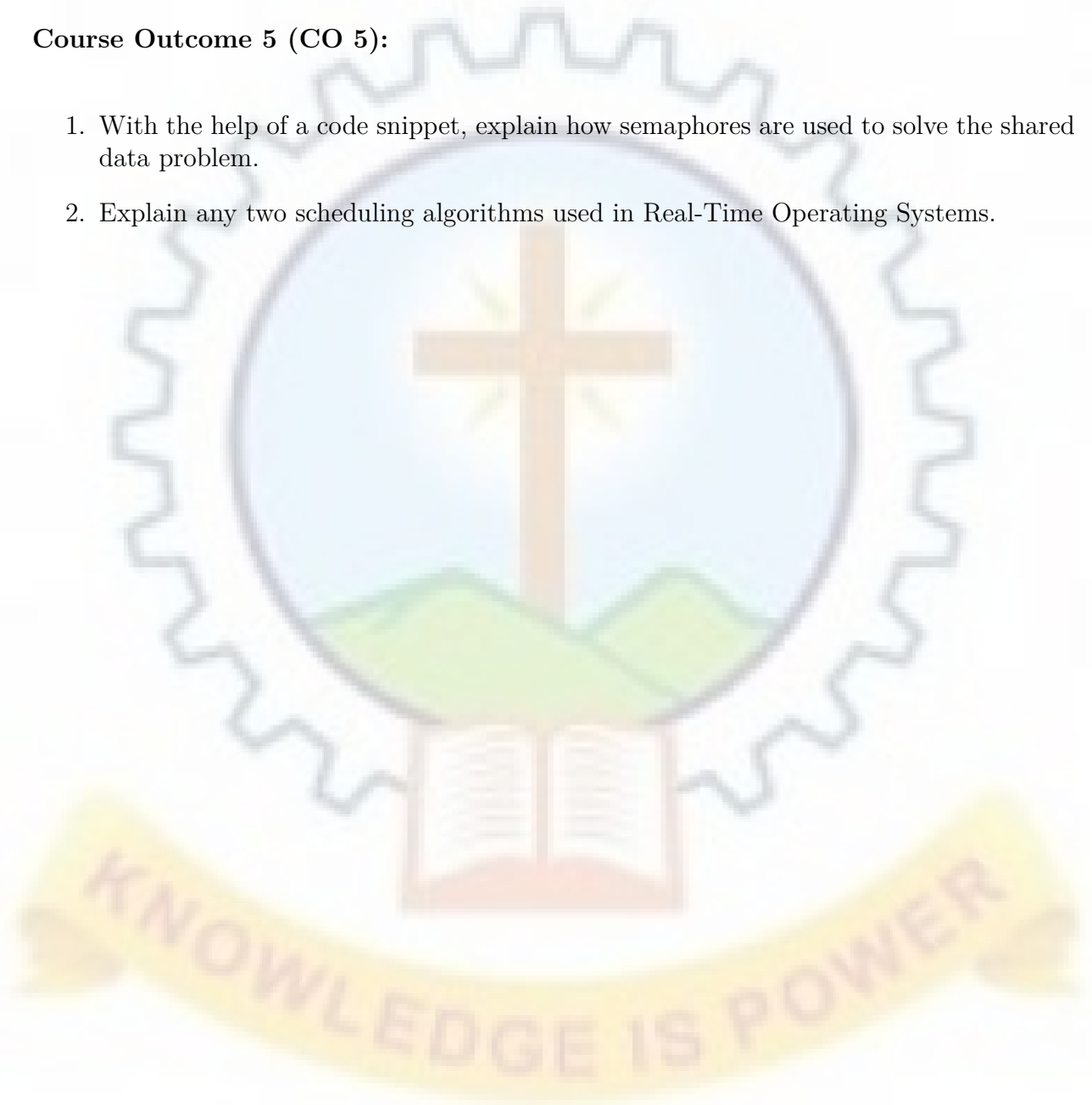
1. If two devices A and B connected to a 'CAN' bus try to transmit data at the same time, what will be the result? Justify your answer. (Assume that ID of device A is 127 and ID of B is 129).
2. With the help of a diagram, explain how a DMA operation takes place.

**Course Outcome 4 (CO 4):**

1. Differentiate between RISC and CISC architectures.
2. Develop an embedded C program for the STM32 microcontroller to toggle the status of an LED every 1 second.

**Course Outcome 5 (CO 5):**

1. With the help of a code snippet, explain how semaphores are used to solve the shared data problem.
2. Explain any two scheduling algorithms used in Real-Time Operating Systems.





**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 3**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DEC 2026**

**Course Code: B24EC3T05**

**Course Name: EMBEDDED SYSTEMS**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Justify why a PC is not considered as an embedded system.
2. Differentiate between an ASIC and a General Purpose processor.
3. As an embedded system designer, draw the block diagram of an MP3 player-cum-recorder and mention the functionality of each component.
4. Draw the circuit diagram for interfacing DS12887 Real Time Clock with 8051 micro-controller.
5. An HDLC transmitter has to send a bit stream '111000111110111111001' using HDLC synchronous link. Compose the data field that will actually be transmitted after bit stuffing and justify your answer.
6. List different data transfer types supported by USB Bus. Also, give one application for each type.
7. Compare RISC and CISC architectures and mention any 3 differences.
8. Develop an embedded C code snippet for STM32 microcontroller to turn on an LED whenever a button is pressed.
9. Summarize the features of a real-time operating system.
10. With the help of a diagram, mention the contents of a Task Control Block.

## PART B

**Answer any one question from each module. Each question carries 14 marks**

### Module I

11. a) Explain the Waterfall model for embedded system development. (7)  
b) Explain the general structure of embedded system hardware with the help of a diagram. (7)
12. a) Explain the different types of processors used in embedded systems and their main features. (7)  
b) With the help of a diagram, explain the architecture of a System-on-Chip. (7)

### Module II

13. A 12-key matrix keypad (4 rows x 3 columns) is needed in an embedded device. Draw and explain the interfacing diagram for the same using an 8051 microcontroller. Also, write a C program to scan the keypad and send hexadecimal code of the pressed key to an output port. (14)
14. a) A sensor produces an output voltage proportional to the atmospheric temperature, given by the relation  $V_{out} = 0.03 * T$  volts (where T is the temperature in  $^{\circ}C$ ). It has to be operated on a range of  $0^{\circ}C - 100^{\circ}C$ . Design a circuit using 8051 microcontroller to display the temperature on an LCD display. (7)  
b) Design a digital camera with various features that are commonly available today. With the help of a simple hardware block diagram, explain its working. (7)

### Module III

15. a) With the help of diagrams, explain about  $I^2C$  protocol used in embedded systems. (7)  
b) An embedded system contains 4 KB of ROM, 1 KB of RAM, 512 bytes of EEPROM, and 128 KB of memory expansion card. Create a memory map for the system and explain. (7)
16. a) List various functions present in a device driver for Interrupt handling. With the help of a sample code snippet, explain the basic actions that are performed inside Interrupt Service Routine function in the device driver. (7)  
b) With the help of a diagram, explain how two modules can be interfaced through SPI. (7)

### Module IV

17. a) With a neat diagram, explain the architecture of the ARM processor. (6)

- b) Develop an embedded C program for STM32 microcontroller to display the text "RISC" on an LCD. (8)
- 18. a) Explain the five stage pipeline organization in the ARM processor. (6)
- b) Develop an embedded C program to generate a triangular waveform of amplitude 1.0 V using an STM32 microcontroller. (8)

**Module V**

- 19. a) Explain the concept of mailbox and message queue used in Inter-process communication. (7)
- b) Explain remote procedure call with an example. (7)
- 20. a) Explain the services provided by an OS Kernel. (7)
- b) Explain the functions of Process Control Block with the help of a diagram. (7)

| B24EC3P11 | SCIENTIFIC<br>COMPUTING<br>USING PYTHON | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|-----------------------------------------|---|---|---|---|--------|-------------------------|
|           |                                         | 2 | 1 | 0 | 4 |        |                         |

### Preamble

This course introduces Python programming, covering fundamentals, data structures, control flow, functions, and object-oriented concepts. Students will gain practical skills in data handling, analysis, and visualization using NumPy, Pandas, and Matplotlib, preparing them for problem-solving and scientific computing applications.

### Prerequisites

B24ES1T01A : PROBLEM SOLVING AND PROGRAMMING TECHNIQUES(A)

B24ES1L01A : PROGRAMMING LAB(A)

### Course Outcomes

After the completion of the course, the student will be able to:

|      |                                                                                                                                                                                        |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Write Python programs using basic syntax, data types, control structures, loops, functions, and fundamental data structures to solve simple computational problems. [Understand/Apply] |
| CO 2 | Design and implement object-oriented programs in Python using classes, objects, constructors, methods, and encapsulation principles. [Apply]                                           |
| CO 3 | Apply advanced object-oriented concepts such as inheritance, polymorphism, abstract classes, and modular programming to develop reusable Python programs. [Apply]                      |
| CO 4 | Perform numerical computations and visualize scientific data using NumPy arrays and Matplotlib plotting techniques. [Apply]                                                            |
| CO 5 | Analyze and process datasets using Pandas by performing data cleaning, filtering, grouping, aggregation, and basic exploratory data analysis. [Apply]                                  |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    | 1    | 1    | 2    | 1    |      | 1    | 1    | 1     | 2     |
| CO 2 | 2    | 3    | 2    | 2    | 3    | 2    | 1    | 2    | 2    | 1     | 2     |
| CO 3 | 3    | 2    | 3    | 2    | 2    | 1    | 1    | 2    | 2    | 2     | 2     |
| CO 4 | 2    | 2    | 3    | 2    | 2    | 2    | 1    | 2    | 2    | 2     | 2     |
| CO 5 | 2    | 2    | 3    | 3    | 3    | 2    | 1    | 2    | 2    | 2     | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 30                    | 30                 | 30                                    |
| Apply            | 50                    | 50                 | 50                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Introduction to Python and Basic Programming Concepts:** Introduction, basic syntax and indentation, variables and expressions, input/output operations, data types – int, float, str, bool, operators, control flow statements (if, elif, else), loops (for, while), functions, arguments, return values, local and global variables, and recursive functions.

Lists, tuples, sets, dictionaries, indexing and slicing, basic string operations, list and dictionary comprehensions, file handling with text and CSV files, and basic exception handling using try-except.

### MODULE 2

**Object-Oriented Programming:** Object-oriented programming concepts – classes and objects, creation of objects, use of constructors to initialize objects, class and instance variables, management of namespaces, definition and invocation of methods, encapsulation, and simple examples.

### MODULE 3

**Advanced OOP Concepts and Modular Programming:** Inheritance and polymorphism, utilization of the super() function to access parent class methods, implementation of abstract classes and interfaces to enforce structure, modules and packages.

### MODULE 4

**Scientific Computing and Visualization:** Numerical computing with NumPy – ndarray creation, array attributes, indexing and slicing, reshaping and broadcasting, basic mathematical and statistical operations, random number generation, and basic linear algebra using numpy.linalg.

Matplotlib 2D plots – line, scatter, bar, and histogram plots with labels and titles, saving plots to files, and visualization of numerical datasets.

### MODULE 5

**Data Analysis Using Pandas:** Introduction to Pandas, Series and DataFrames; reading data from CSV and Excel files; data inspection and cleaning; handling missing values; indexing, slicing, filtering, and conditional selection.

Descriptive statistics, sorting and grouping data using groupby, basic aggregation, merging datasets, and introductory time-series handling.

### Text Books

1. A Primer on Scientific Programming with Python – Hans Petter Langtangen, Springer,



5th Edition (2016).

2. Python for Scientists and Engineers – Suresh Chandra and Aarti Singh, Springer, 1st Edition (2015).

3. Think Python – Allen B. Downey, O'Reilly Media, 2nd Edition (2015).

4. Python for Everybody: Exploring Data in Python 3 – Charles R. Severance, Shroff Publishers and Distributors (SPD), 1st Edition (2017).



TBdf\*\*\*\*\*

## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                  | No of Lecture/Tutorial Hours |
|-----|------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                        | <b>8</b>                     |
| 1.1 | Introduction to Python, basic syntax and indentation.                  | 1                            |
| 1.2 | Variables and expressions, input/output operations.                    | 1                            |
| 1.3 | Data types – int, float, str, bool and operators.                      | 1                            |
| 1.4 | Control flow statements: if, elif, else.                               | 1                            |
| 1.5 | Loops: for and while loops, iteration examples.                        | 1                            |
| 1.6 | Functions, arguments, return values, local and global variables.       | 2                            |
| 1.7 | Recursive functions and simple problem-solving exercises.              | 1                            |
|     | <b>Module 2</b>                                                        | <b>8</b>                     |
| 2.1 | Lists, tuples, sets, and dictionaries – creation and operations.       | 2                            |
| 2.2 | Indexing, slicing, comprehensions, aliasing, mutability, and cloning.  | 1                            |
| 2.3 | String operations and manipulations.                                   | 1                            |
| 2.4 | File handling: reading and writing text and CSV files.                 | 2                            |
| 2.5 | Error handling using try-except and simple scripting applications.     | 2                            |
|     | <b>Module 3</b>                                                        | <b>7</b>                     |
| 3.1 | Object-oriented programming: classes and objects, creation of objects. | 1                            |
| 3.2 | Constructors and initialization of objects.                            | 1                            |
| 3.3 | Class and instance variables, managing namespaces.                     | 1                            |
| 3.4 | Definition and invocation of methods, encapsulation.                   | 2                            |
| 3.5 | Simple examples demonstrating OOP concepts.                            | 2                            |
|     | <b>Module 4</b>                                                        | <b>5</b>                     |
| 4.1 | Inheritance and polymorphism, the use of super() function.             | 2                            |
| 4.2 | Abstract classes and interfaces: purpose and implementation.           | 1                            |
| 4.3 | Working with modules and packages.                                     | 2                            |
|     | <b>Module 5</b>                                                        | <b>8</b>                     |
| 5.1 | NumPy arrays: creation, indexing, slicing, reshaping.                  | 2                            |

|                    |                                                                                                               |                 |
|--------------------|---------------------------------------------------------------------------------------------------------------|-----------------|
| 5.2                | Mathematical and linear algebra operations using numpy.linalg.                                                | 1               |
| 5.3                | Random number generation and statistical basics.                                                              | 1               |
| 5.4                | Matplotlib 2D plots: line, scatter, bar, and histogram with labels and titles.                                | 2               |
| 5.5                | Pandas DataFrames and Series: reading data from CSV/Excel, data cleaning, statistics, filtering and grouping. | 2               |
| <b>Total Hours</b> |                                                                                                               | <b>36 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Write a Python program to check whether a given number is prime or not. The program should take input from the user and display an appropriate message. Include proper use of conditional statements and loops.
2. Write a Python program that takes an integer input n from the user and prints the factorial of n using a recursive function. Explain how recursion works in your program.

#### Course Outcome 2 (CO 2):

1. Write a Python program to read a list of numbers from the user, remove duplicates, and display the sorted list. Demonstrate the use of lists, sets, indexing, slicing, and comprehensions.
2. Write a Python program to read a text file of student names and marks, calculate the average, and list students scoring above average. Include error handling for missing files or incorrect formatting.

#### Course Outcome 3 (CO 3):

1. Write a Python program to define a class Rectangle with attributes length and width, methods to calculate area and perimeter, and a constructor to initialize the values. Create objects and display their results.
2. Write a Python program that defines a class Book with attributes title, author, and price. Include methods to display book details and apply a discount on the price. Create multiple objects and show their updated information.

**Course Outcome 4 (CO 4):**

1. Create a Python program that demonstrates method overriding and polymorphism using a base class Shape and derived classes Circle and Rectangle, each implementing their own area() method.
2. Design a Python package named mathutils containing separate modules for arithmetic and geometric operations. Import and use these modules in a main program to perform computations.

**Course Outcome 5 (CO 5):**

1. Write a Python program using NumPy to create an array of random integers, reshape it into a matrix, and compute its mean and transpose.
2. Write a Python program to plot line and scatter graphs using Matplotlib for two given datasets. Include appropriate axis labels, title, and legend.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2026**

**Course Code: B24EC3P11**

**Course Name: SCIENTIFIC COMPUTING USING PYTHON**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Differentiate between local and global variables in Python using a short code snippet.
2. What is a recursive function? Write a simple recursive function to find the factorial of a number.
3. What are the main differences between lists and tuples in Python?
4. Define aliasing. How is it different from cloning in Python?
5. Define a class in Python. Give a simple example.
6. Give an example of creating multiple objects from the same class.
7. What is inheritance in Python? Give an example of single inheritance.
8. How does the super() function work in Python? Give a short example.
9. How do you create a NumPy array from a Python list? Give an example.
10. Explain indexing and slicing in NumPy arrays with an example.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Describe the various input and output operations in Python. How can formatted output be achieved using the format() method? (7)  
b) Write a Python program to calculate the simple and compound interest for given principal, rate, and time using user-defined functions. (7)
12. a) Describe the different data types in Python with examples. How are mutable and immutable types different? (7)  
b) Write a Python program that reads a string from the user and counts the number of vowels, consonants, digits, and special characters. (7)

#### **Module II**

13. a) Explain different sequence data types in Python (lists, tuples, strings) with their key properties and use cases. (7)  
b) Write a Python script that reads a CSV file containing student marks and computes the average marks for each student. (7)
14. a) Discuss mutability and immutability in Python with suitable examples. (7)  
b) Write a Python program to read a text file, count the number of words, and display the number of times each word occurs in the file. (7)

#### **Module III**

15. a) Explain the concepts of class and object in Python with examples. (7)  
b) Write a Python program to define a class Student with attributes name and marks, and a method to display the student details. Create two objects and display their information. (7)
16. a) Explain namespaces in Python classes and their importance in object-oriented programming. (7)  
b) Write a Python program to demonstrate method invocation where a class Calculator has methods for addition, subtraction, multiplication, and division. Create an object and call all methods. (7)

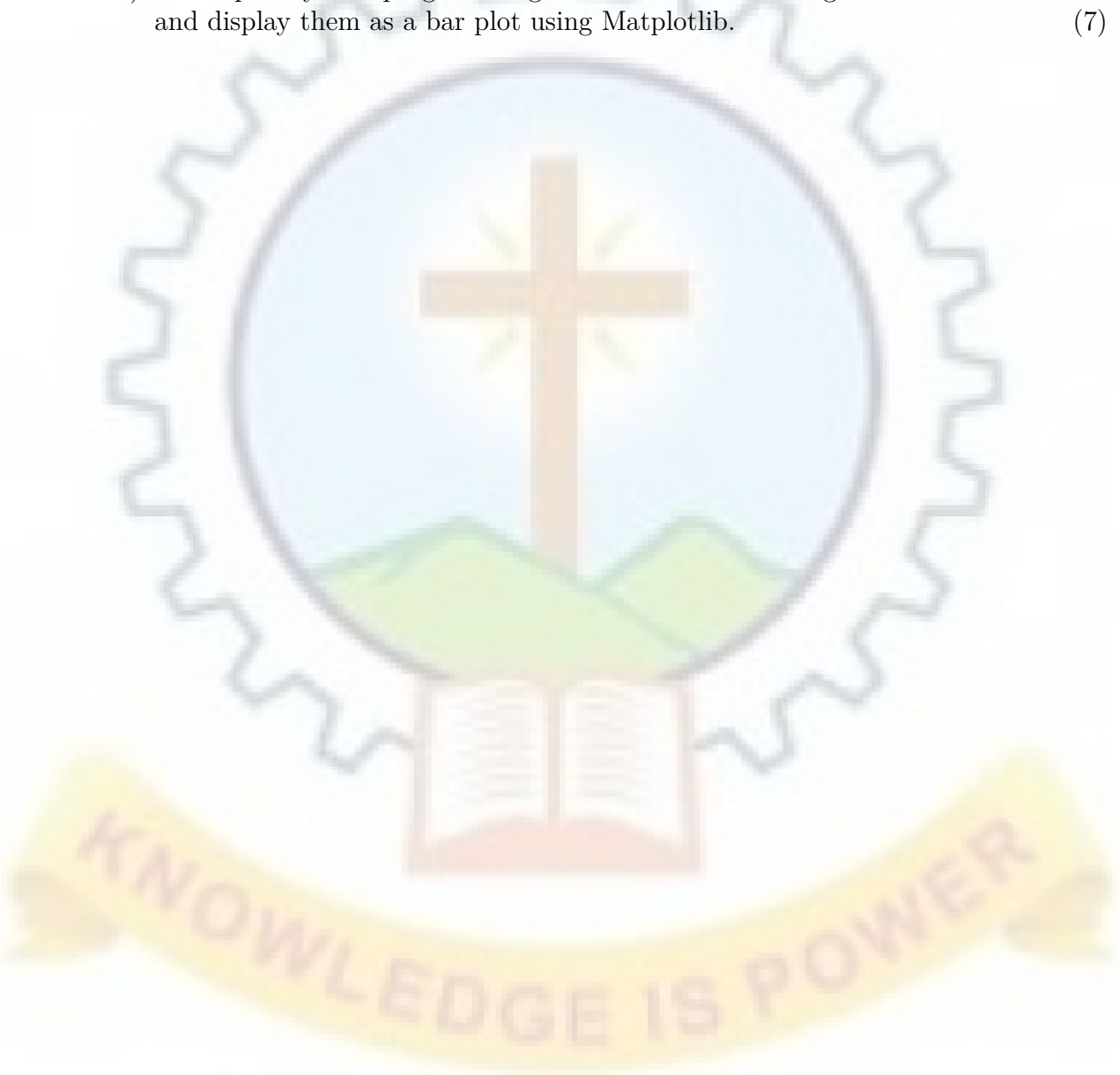
#### **Module IV**

17. a) What is polymorphism in Python? Explain method overriding and operator overloading with examples. (7)  
b) Write a Python program to demonstrate single inheritance. Create a parent class Vehicle and a child class Car with additional attributes. (7)
18. a) What are abstract classes and interfaces? How do they enforce structure in Python programs? (7)  
b) Create a Python program using super() to call the parent class constructor. Example: Parent class Person and child class Student. (7)



**Module V**

19. a) Explain linear algebra operations using numpy.linalg with suitable examples. (7)  
b) Write a Python program to create a 3×3 NumPy array and compute the sum, mean, and transpose of the array. (7)
20. a) Explain the structure of Pandas Series and DataFrame, including reading data from CSV/Excel files and performing descriptive statistics. (7)  
b) Develop a Python program to generate 10 random integers between 1 and 100 and display them as a bar plot using Matplotlib. (7)



| B24EC3P12 | INSTRUMENTATION AND INDUSTRIAL AUTOMATION | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|-------------------------------------------|---|---|---|---|--------|----------------------|
|           |                                           | 2 | 1 | 0 | 4 | 3      | 2024                 |

### Preamble

This course provides an understanding of the principles, components, and applications of measurement and control systems used in industrial and automation environments. It emphasizes sensors, signal conditioning, data acquisition, and modern control interfaces such as PLC, SCADA, and HMI.

### Prerequisites

B24EC2T03 ANALOG CIRCUITS 2  
B24EC2T05 SIGNALS AND SYSTEMS

### Course Outcomes

After the completion of the course, the student will be able to:

|      |                                                                                                                                |
|------|--------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Explain the fundamentals of measurement systems, instrumentation, and performance characteristics.. [Understand]               |
| CO 2 | Identify and describe various sensors and transducers used for measuring physical parameters.[Remember/Understand]             |
| CO 3 | Analyze the working of signal conditioning and data acquisition systems including smart sensors and MEMS.[Analyze]             |
| CO 4 | Apply measurement principles to real-world case studies and select suitable sensors for specific applications.[Analyze, Apply] |
| CO 5 | Illustrate the operation of process control systems, controllers, PLCs, and SCADA with HMI integration[Understand, Apply]      |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    | 1    |      | 2    |      | 2    |      |      |       | 2     |
| CO 2 | 3    | 2    |      | 2    | 2    | 1    |      | 2    |      |       | 2     |
| CO 3 | 3    | 3    | 2    | 3    | 2    |      |      |      |      |       |       |
| CO 4 | 3    | 3    | 3    | 3    | 2    | 3    | 3    | 1    | 2    | 3     | 3     |
| CO 5 | 3    | 2    | 3    | 2    | 3    | 2    |      | 1    |      | 1     |       |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 50                    | 30                 | 40                                    |
| Understand       | 50                    | 30                 | 40                                    |
| Apply            |                       | 20                 | 10                                    |
| Analyse          |                       | 20                 | 10                                    |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Measurement Systems:** Basic Instrumentation Systems, Performance Terms, Static and Dynamic characteristics, Selection criteria of transducers.

### MODULE 2

**Sensors and Transducers:** Instrumentation System Elements, Resistive, Displacement Sensors, Speed Sensors, Pressure Sensors, Flow sensors, Liquid Level sensors, Temperature Sensors.

### MODULE 3

**Signal Conditioning and Data Acquisition :** Analog Signal Conditioning, Digital Signal Conditioning. Data acquisition systems. Smart sensors and MEMS. Signal transmission. Data presentation element.

### MODULE 4

**Measurement Case Studies :** Introduction, A temperature measurement, An absolute pressure measurement, Detection of the angular position of a shaft, Air flow rate determination, Fluid level monitoring , Measurement of relative humidity, Dimension checking, Temperature of a furnace, Automobile tyre pressure monitoring, Control system sensors with automobiles.

### MODULE 5

**Control Systems and Process Controllers:** Basics of process control, Types of controllers: PID, PLC, DCS. Introduction to PLCs, Programming languages and ladder logic.

#### Text Books

1. Bolton, W., 2021. Instrumentation and control systems. Newnes.
2. Curtis D Johnson, 2014. *Process control instrumentation technology*. Prentice Hall PTR
3. DVS. Murty, "Transducers and Instrumentation", Second Edition, PHI Learning Pvt Ltd New Delhi, 2013
4. Jovitha Jerome, "Virtual instrumentation using LabVIEW", Prentice Hall of India, 2010
5. Doebelin E.O, "Measurement Systems: Application and Design", Fourth Edition, McGraw Hill, Newyork, 1992

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                                                                                                                                                | No of Lecture/Tutorial Hours |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                                                      | <b>5</b>                     |
| 1.1 | Introduction,Block diagram representation of instrumentation system                                                                                                                  | 1                            |
| 1.2 | Performance Terms – Accuracy, precision, resolution, sensitivity, range, repeatability, reproducibility                                                                              | 1                            |
| 1.3 | Static Characteristics – Static error, hysteresis,stability, resolution                                                                                                              | 1                            |
| 1.4 | Dynamic Characteristics                                                                                                                                                              | 1                            |
| 1.5 | Selection criteria of transducers-Factors affecting choice: range, sensitivity, loading, environmental conditions, cost.                                                             | 1                            |
|     | <b>Module 2</b>                                                                                                                                                                      | <b>8</b>                     |
| 2.1 | Instrumentation System Elements – Sensing element, transduction element, signal conditioning, data presentation                                                                      | 1                            |
| 2.2 | Resistive and displacement sensors–Potentiometer, Strain-Gauged Element, Capacitive Element, Linear Variable Differential Transformer, Optical Encoders, Optical Proximity Sensors . | 2                            |
| 2.3 | Speed Sensors- Optical Methods, Incremental Encoder, Tachogenerator. Pressure Sensors- Diaphragm Sensor, Piezoelectric Sensor Bourdon tube, diaphragm, bellows, strain gauge         | 2                            |
| 2.4 | Flow sensors-Orifice, venturi, rotameter, turbine, ultrasonic flowmeters . Liquid Level sensors- Float-type, resistive, capacitive, ultrasonic                                       | 2                            |
| 2.5 | Temperature Sensors- Thermocouples, RTDs, thermistors, semiconductor sensors.                                                                                                        | 1                            |
|     | <b>Module 3</b>                                                                                                                                                                      | <b>7</b>                     |
| 3.1 | Resistance to Voltage Converter, Temperature Compensation,Thermocouple Compensation, Protection                                                                                      | 1                            |
| 3.2 | Analogue-to-Digital Conversions,Digital-to-Analogue Conversions                                                                                                                      | 2                            |
| 3.3 | Microcontroller Systems, Op-Amps, Pressure-to-Current Converter                                                                                                                      | 1                            |
| 3.4 | Data Acquisition Systems (DAS) — Elements of DAS; types (analog and digital),Data Acquisition Software,Data Loggers . .                                                              | 1                            |

|     |                                                                                                                                                                     |                 |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 3.5 | Smart Sensors and MEMS — Concept of smart sensors. MEMS technology and applications in modern instrumentation.                                                      | 1               |
| 3.6 | Signal Transmission and Data Presentation — Different signal transmission methods, Noise-Commonly used data presentation methods.                                   | 1               |
|     | <b>Module 4</b>                                                                                                                                                     | <b>8</b>        |
| 4.1 | Introduction to Measurement Case Studies — Purpose and importance                                                                                                   | 1               |
| 4.2 | Temperature Measurement Case Study and Absolute Pressure Measurement                                                                                                | 1               |
| 4.3 | Angular Position Detection of a Shaft and air flow rate determination                                                                                               | 1               |
| 4.4 | Fluid Level Monitoring and Relative Humidity Measurement .                                                                                                          | 2               |
| 4.5 | Dimension checking, Temperature of a furnace and Automobile tyre pressure monitoring,                                                                               | 1               |
| 4.6 | Automobile tyre pressure monitoring, Control system sensors with automobiles.                                                                                       | 2               |
|     | <b>Module 5</b>                                                                                                                                                     | <b>8</b>        |
| 5.1 | Introduction to process control                                                                                                                                     | 1               |
| 5.2 | Types of Controllers — On-off, proportional, integral, derivative, and PID controllers; combined control actions; tuning and performance characteristics.           | 1               |
| 5.3 | Introduction to PLCs (Programmable Logic Controllers) — Basic architecture, input/output modules, scan cycle, advantages over relay-based systems.                  | 2               |
| 5.4 | PLC Programming Languages and Ladder Logic — IEC 61131 standard languages; ladder diagram symbols, logic operations, timers, counters, and simple control examples. | 2               |
| 5.5 | Distributed Control Systems (DCS) and Applications — DCS architecture, comparison with PLC,                                                                         | 2               |
|     | <b>Total Hours</b>                                                                                                                                                  | <b>36 Hours</b> |



## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1):**

1. Define static and dynamic characteristics of instruments.
2. Explain the components of a basic instrumentation system with a neat block diagram.
3. Discuss how the performance characteristics influence the selection of transducers.

### **Course Outcome 2 (CO 2):**

1. List various types of temperature sensors and their working principles.
2. Compare resistive and capacitive displacement sensors.
3. Design a sensor system for monitoring liquid level in a tank.

### **Course Outcome 3 (CO 3):**

1. What is the role of signal conditioning in measurement systems?
2. Differentiate between analog and digital signal conditioning.
3. Explain the architecture of a data acquisition system with smart sensors and MEMS.

### **Course Outcome 4 (CO 4):**

1. What are the steps involved in measuring the angular position of a shaft?
2. Describe a case study for measuring furnace temperature.
3. Suggest suitable sensors for automobile tyre pressure monitoring and justify your choice.

### **Course Outcome 5 (CO 5):**

1. Define PID control and its importance in process control systems.
2. Explain PLC architecture and ladder logic programming with an example.
3. Discuss the integration of SCADA and HMI for industrial automation.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2026**

**Course Code: B24EC3P12**

**Course Name: Instrumentation and Industrial Automation**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define static and dynamic characteristics of an instrumentation system.
2. Explain the key elements of a basic measurement system.
3. What factors influence the selection of transducers for a specific application?
4. Differentiate between resistive and inductive displacement sensors.
5. List the types of temperature sensors and state one application for each.
6. What are the functions of signal conditioning in a data acquisition system?
7. Define smart sensors. How do they differ from conventional sensors?
8. What is the significance of data presentation elements in measurement systems?
9. Describe a case study involving the measurement of fluid level in a tank.
10. What is the importance of process controllers in industrial automation?

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain the components and working of a basic instrumentation system with a neat block diagram. (7)  
b) Define and compare static and dynamic characteristics of measuring instruments with examples. (7)
12. a) Describe the performance terms used in measurement systems such as accuracy, precision, and linearity. (7)  
b) Explain the selection criteria of transducers for different measurement applications. (7)

**Module II**

13. a) Discuss the working principles of resistive and capacitive displacement sensors. (7)  
b) Explain the construction and operation of speed and pressure sensors used in industrial applications.. (7)
14. a) Describe various types of flow and liquid level sensors with neat diagrams. (7)  
b) Compare thermocouples, RTDs, and thermistors in terms of working principle and characteristics. (7)

**Module III**

15. a) Explain the architecture of an analog and digital signal conditioning system. (7)  
b) Describe the structure and working of a data acquisition system. (7)
16. a) Discuss the role of smart sensors and MEMS in modern measurement systems. (7)  
b) Explain signal transmission and data presentation elements used in data acquisition. (7)

**Module IV**

17. Analyze the measurement system for automobile tyre pressure monitoring. Explain the principle, sensors used, and interfacing requirements.. (14)
18. Discuss in detail any two case studies from the following: a) Furnace temperature measurement b) Airflow rate determination c) Fluid level monitoring system Provide schematic diagrams and suitable sensor justifications.. (14)

**Module V**

19. a) Explain the working of PID controllers and discuss their role in process control loops. (7)  
b) Describe the architecture and programming of PLCs using ladder logic with an exam (7)

20. a) What is SCADA? Explain the architecture and components of a SCADA system. (7)
- b) Describe the role of Human-Machine Interface (HMI) in monitoring and control applications. (7)



| <b>B24EC3P13</b> | <b>OPTICAL FIBER COMMUNICATION</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF INTRODUCTION</b> |
|------------------|------------------------------------|----------|----------|----------|----------|---------------|-----------------------------|
|                  |                                    | 2        | 1        | 0        | 4        |               |                             |

**Preamble**

This course aims to introduce the concepts of light transmission through optical fibers and introduce the working of optical components.

**Prerequisites**

Basic Concepts of Solid State Devices - B24EC2T04

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                   |
|-------------|-------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the working and classification of optical fibers in terms of propagation modes. [Understand, Apply]    |
| <b>CO 2</b> | Solve problems of transmission characteristics and losses in optical fiber. [Understand, Apply]                   |
| <b>CO 3</b> | Explain the constructional features and the characteristics of optical sources and detectors. [Understand, Apply] |
| <b>CO 4</b> | Describe the operations of optical amplifiers. [Understand, Apply]                                                |
| <b>CO 5</b> | Understand the concept of WDM, FSO and LiFi. [Understand, Apply]                                                  |

**Mapping of Course Outcomes With Program Outcomes**

|             | <b>PO 1</b> | <b>PO 2</b> | <b>PO 3</b> | <b>PO 4</b> | <b>PO 5</b> | <b>PO 6</b> | <b>PO 7</b> | <b>PO 8</b> | <b>PO 9</b> | <b>PO 10</b> | <b>PO 11</b> |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|
| <b>CO 1</b> | 3           | 3           | 1           | 2           |             | 1           | 1           | 1           | 1           |              | 1            |
| <b>CO 2</b> | 3           | 3           | 2           | 2           | 1           |             | 1           |             |             |              | 1            |
| <b>CO 3</b> | 3           | 3           | 2           |             |             |             | 1           | 1           | 1           | 1            | 1            |
| <b>CO 4</b> | 3           | 3           | 1           |             | 1           | 1           | 1           | 1           |             | 1            | 1            |
| <b>CO 5</b> | 3           | 3           | 2           | 1           | 1           |             | 1           | 1           | 1           |              | 1            |

**Assessment Pattern****Mark Distribution**

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 10                    | 10              | 20                                 |
| Understand       | 30                    | 30              | 60                                 |
| Apply            | 10                    | 10              | 20                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.



## SYLLABUS

### MODULE 1

**Optical fiber Communications:** The general system, Advantages of optical fiber communication, Optical fiber waveguides: Ray theory transmission, Modes in planar guide, Phase and group velocity **Fibres:** Types and refractive index profiles, Step index fibers, Graded index fibers, Single mode fibers, Cutoff wavelength, Mode field diameter, effective refractive index. Fibre materials, photonic crystal fibre, index guiding PCF, photonic band-gap fibres, fibre cables.

### MODULE 2

**Transmission characteristics of optical fiber:** Attenuation, Material absorption losses, Linear scattering losses, Nonlinear scattering losses, Fiber bend loss, Dispersion, Chromatic dispersion, Intermodal dispersion: Multimode step index fiber.

**Optical Fiber Connectors:** Fiber alignment and joint loss, Fiber splices, Fiber connectors, Fiber couplers.

### MODULE 3

**Optical sources:** LEDs and LDs, structures, characteristics, modulators using LEDs and LDs. coupling with fibres, noise in Laser diodes, Amplified Spontaneous Emission noise, effects of Laser diode noise in fibre communications.

**Optical detectors:** Types and characteristics, structure and working of PIN and AP, noise in detectors, comparison of performance. Optical receivers, Ideal photo receiver and quantum limit of detection.

### MODULE 4

**Optical Amplifiers:** basic concept, applications, types, doped fibre amplifiers, EDFA, basic theory, structure and working, Semiconductor laser amplifier, Raman amplifiers, TDFA, amplifier configurations, performance comparison.

### MODULE 5

The WDM concept, WDM standards, WDM components, couplers, splitters, Add/ Drop multiplexers, gratings, tunable filters. Introduction to free space optics, LiFi technology and VLC. Optical Time Domain Reflectometer (OTDR) – fault detection length and refractive index measurements.

**Text Books**

1. Gerd Keiser, Optical Fiber Communications, 5/e, McGraw Hill, 2013.
2. Mishra and Ugale, Fibre optic Communication, Wiley, 2013.
3. Chakrabarthi, Optical Fibre Communication, McGraw Hill, 2015.
4. Hebbar, Optical fibre communication, Elsevier, 2014
5. John M Senior- Optical communications, 3/e, Pearson, 2009.
6. Joseph C. Palais, Fibre Optic Communications, 5/e Pearson, 2013.
7. Keiser, Optical Communication Essentials (SIE), 1/e McGraw Hill Education New Delhi, 2008.



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                    | No of Lecture/Tutorial Hours |
|-----|----------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                          | <b>8</b>                     |
| 1.1 | The general system, Advantages of optical fiber communication.                                           | 1                            |
| 1.2 | Optical fiber waveguides: Ray theory transmission.                                                       | 1                            |
| 1.3 | Modes in planar guide, Phase and group velocity.                                                         | 1                            |
| 1.4 | Fibres: Types and refractive index profiles, Step index fibers, Graded index fibers, Single mode fibers. | 2                            |
| 1.5 | Cutoff wavelength, Mode field diameter, effective refractive index                                       | 1                            |
| 1.6 | Fibre materials, photonic crystal fibre, index guiding PCF, photonic band-gap fibres, fibre cables.      | 2                            |
|     | <b>Module 2</b>                                                                                          | <b>7</b>                     |
| 2.1 | Attenuation, Material absorption losses.                                                                 | 1                            |
| 2.2 | Linear scattering losses.                                                                                | 1                            |
| 2.3 | Nonlinear scattering losses, Fiber bend loss                                                             | 1                            |
| 2.4 | Dispersion, Chromatic dispersion, Intermodal dispersion: Multimode step index fiber                      | 2                            |
| 2.5 | Optical Fiber Connectors: Fiber alignment and joint loss.                                                | 1                            |
| 2.6 | Fiber splices, Fiber connectors, Fiber couplers.                                                         | 1                            |
|     | <b>Module 3</b>                                                                                          | <b>8</b>                     |
| 3.1 | LEDs and LDs, structures, characteristics, modulators using LEDs and LDs                                 | 2                            |
| 3.2 | coupling with fibres, noise in Laser diodes.                                                             | 1                            |
| 3.3 | Amplified Spontaneous Emission noise, effects of Laser diode noise in fibre communications               | 1                            |
| 3.4 | Optical detectors: Types and characteristics, structure and working of PIN and AP                        | 2                            |
| 3.5 | noise in detectors, comparison of performance                                                            | 1                            |
| 3.6 | Optical receivers, Ideal photo receiver and quantum limit of detection.                                  | 1                            |
|     | <b>Module 4</b>                                                                                          | <b>6</b>                     |
| 4.1 | basic concept, applications, types.                                                                      | 1                            |
| 4.2 | doped fibre amplifiers, EDFA, basic theory, structure and working.                                       | 2                            |
| 4.3 | Semiconductor laser amplifier                                                                            | 1                            |
| 4.4 | Raman amplifiers, TDFA.                                                                                  | 1                            |
| 4.5 | amplifier configurations, performance comparison                                                         | 1                            |
|     | <b>Module 5</b>                                                                                          | <b>6</b>                     |
| 5.1 | WDM standards, WDM components                                                                            | 1                            |
| 5.2 | couplers, splitters, Add/ Drop multiplexers                                                              | 1                            |

|     |                                                                                                     |                 |
|-----|-----------------------------------------------------------------------------------------------------|-----------------|
| 5.3 | gratings, tunable filters.                                                                          | 1               |
| 5.4 | Introduction to free space optics, LiFi technology and VLC                                          | 1               |
| 5.5 | Optical Time Domain Reflectometer (OTDR) – fault detection length and refractive index measurements | 2               |
|     | <b>Total Hours</b>                                                                                  | <b>35 Hours</b> |

### CO ASSESSMENT QUESTIONS

**Course Outcome 1 (CO 1):** Know the classification and working of optical fiber with different modes of signal propagation

1. Illustrate the types of optical fibers with refractive index profiles.
2. Define Photonic Crystal Fibers and list the types.
3. What is the necessity of cladding for an optical fiber?

**Course Outcome 2 (CO 2):** Understand the transmission characteristics and losses in optical fiber

1. Describe the various attenuation losses incurred by light signal while transmitting through a fiber.
2. What is meant by group velocity dispersion?
3. An optical fiber has an attenuation coefficient of 0.5dB/km at 1310nm. Find the optical power at 25km if 500 $\mu$ W of optical power is launched into the fiber.

**Course Outcome 3 (CO 3):** Describe the constructional features and the characteristics of optical sources and detectors

1. What is a heterojunction? How it increases the radiance and efficiency of LEDs?
2. Draw the basic block diagram of an optical receiver and explain.

**Course Outcome 4 (CO 4):** Describe the performance of optical amplifiers

1. What are salient features of semiconductor optical amplifiers?
2. Explain the amplification mechanism with energy level diagram in an EDFA.

**Course Outcome 5 (CO 5):** Know the concept of WDM, FSO and LiFi

1. What are the underlying principles of the WDM techniques?
2. Explain in detail diffraction gratings.
3. Write a note on optical Add / Drop multiplexers.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2026**

**Course Code: B24EC3P13**

**Course Name: OPTICAL FIBER COMMUNICATION**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define acceptance angle and critical angle.
2. What is the necessity of cladding for an optical fiber?
3. What is meant by group velocity dispersion?
4. Explain intermodal dispersion?
5. Differentiate between spontaneous and stimulated emission.
6. Draw the three key transition process involved in LASER action.
7. Compare EDFA and TDFA
8. What is the principle of Raman amplifiers?
9. Define FSO concept. List the advantages.
10. Write short note on LiFi technology.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**



11. a) With block diagram explain a general light wave system. What are the advantages of optical communication? (7)
- b) Consider an optical fiber of 50  $\mu\text{m}$  diameter, core index  $n_1 = 1.5$ , cladding index  $n_2 = 1.49$  for operation at  $\lambda = 1.31\mu\text{m}$ . How many modes does this fiber support? (7)
12. a) Illustrate the types of optical fibers with refractive index profiles. (6)
- b) Explain the following : (i) Acceptance angle (ii) Numerical aperture If for a given optical fiber the refractive index of cladding and core are 1.45 and 1.47 respectively, calculate the numerical aperture and angle of acceptance in air. (8)

**Module II**

13. a) Explain macro bending and micro bending losses with a neat diagram.. (10)
- b) An optical fiber has an attenuation coefficient of 0.5dB/km at 1310nm. Find the optical power at 25km if 500 $\mu\text{W}$  of optical power is launched into the fiber. (4)
14. a) Describe the various attenuation losses incurred by light signal while transmitting through a fiber. (9)
- b) Given an optical fiber of 50  $\mu\text{m}$  diameter, core index of 1.5, and cladding index 1.49 for operation at  $\lambda = 1.31\mu\text{m}$ . What would be the pulse spread due to modal dispersion over a distance of 10 km? (5)

**Module III**

15. a) With neat sketch explain the working of pin photodiode and APD (10)
- b) What is meant by responsivity? How it is related to quantum efficiency? (4)
16. a) What is a heterojunction? How it increases the radiance and efficiency of LEDs? (7)
- b) Draw the basic block diagram of an optical receiver and explain.. (7)

**Module IV**

17. a) Explain the amplification mechanism with energy level diagram in an EDFA.(8)
- b) Compare the performance of different optical amplifiers.
18. a) Explain the working of semiconductor optical amplifiers. What are salient features of semiconductor optical amplifiers? (7)
- b) What are different amplifier configurations? Explain the basic working principle of optical amplifiers. (7)

**Module V**

19. a) With neat sketch explain WDM scheme. (7)

- b) Illustrate the working principle of diffraction gratings. (7)
20. a) Explain with block diagram the working of optical add / drop multiplexer. Explain why it is required in optical communication system. (7)
- b) How does an OTDR works? Explain the fault detection and refractive index measurement. (7)



| B24EC3P14 | DIGITAL<br>SYSTEM DESIGN | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|--------------------------|---|---|---|---|--------|-------------------------|
|           |                          | 2 | 1 | 0 | 4 |        |                         |

**Preamble**

This course aims to design hazard free sequential circuits and implement the same in the appropriate hardware device.

**Prerequisites**

B24EC1T03 : LOGIC CIRCUIT DESIGN

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                           |
|-------------|---------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Design and analyze clocked synchronous sequential circuits. [Understand,Apply]                                            |
| <b>CO 2</b> | Design and analyze asynchronous sequential circuits. [Understand, Apply]                                                  |
| <b>CO 3</b> | Design hazard free circuits. [Understand, Apply]                                                                          |
| <b>CO 4</b> | Diagnose faults in digital circuits. [Understand, Apply]                                                                  |
| <b>CO 5</b> | Design simple digital systems with programmable logic devices and summarize the architecture of PLDs. [Understand, Apply] |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO<br>1 | PO<br>2 | PO<br>3 | PO<br>4 | PO<br>5 | PO<br>6 | PO<br>7 | PO<br>8 | PO<br>9 | PO<br>10 | PO<br>11 |
|-------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|
| <b>CO 1</b> | 3       | 3       | 3       |         | 2       |         |         |         | 2       | 2        | 3        |
| <b>CO 2</b> | 3       | 3       |         |         | 2       |         |         |         | 2       | 2        | 3        |
| <b>CO 3</b> | 3       | 3       | 3       | 3       |         |         |         |         | 2       | 2        | 3        |
| <b>CO 4</b> | 3       | 2       |         | 1       |         |         |         |         | 2       | 2        | 3        |
| <b>CO 5</b> | 2       |         |         |         |         |         |         |         | 2       | 2        | 3        |

**Assessment Pattern****Mark Distribution**

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 30                    | 30                 | 30                                    |
| Apply            | 50                    | 50                 | 50                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**State Machines Models :** Mealy and Moore state machine models. State diagram(both moore and mealy),State table, State transition table, Excitation table, State equations.State reduction – equivalence classes, implication chart method. ASM Chart-Moore and Mealy ASM Chart.

### MODULE 2

**Design and Analysis of Digital Networks:** Clocked Synchronous Networks:Structure of Clocked Synchronous Sequential Networks (CSSN),Design of CSSN,Analysis of clocked Synchronous Sequential Networks (CSSN). Asynchronous Sequential Circuits:Flow table reduction- Races in ASC, State assignment problem and the transition table.Design of ASC.Analysis of Asynchronous Sequential Circuits (ASC).

### MODULE 3

**Hazards:** Hazards – static, dynamic and essential hazards, Design of Hazard free circuits – Data synchronizers, Mixed operating mode asynchronous circuits, Practical issues- clock skew and jitter, Synchronous and asynchronous inputs – switch bouncing.

### MODULE 4

**Faults:** Faults-types,Fault detection-Fault table method ,path sensitization method ,Boolean difference method, Kohavi algorithm, Automatic test pattern generation – Built in Self Test (BIST).

### MODULE 5

**Programmable logic Devices:** Digital system design options and tradeoffs, Design methodology and technology-Overview. Programmable logic Devices: ROM, PLA, PAL, CPLD, FPGA Features, Limitations,Architectures and Programming. Implementation of MSI circuits using Programmable logic Devices.FPGAs – Xilinx XC 4000 FPGA family – configurable logic block - input output block, Programmable interconnect

### Text Books

1. Donald G Givone, Digital Principles & Design, Tata McGraw Hill, 2003
2. John F Wakerly, Digital Design, Pearson Education, Delhi 2002

3. John M Yarbrough, Digital Logic Applications and Design, Thomson Learning
4. Miron Abramovici, Melvin A. Breuer and Arthur D. Friedman, Digital Systems Testing and Testable Design, John Wiley & Sons Inc.
5. Digital Design Using Field Programmable Gate Array, P.K. Chan & S. Mourad, 1994, Prentice Hall
6. Samuel C. Lee, Digital Circuits and Logic Design, PHI
7. Z. Kohavi, Switching and Finite Automata Theory, 2nd ed., 2001, TMH





**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                  | <b>No of Lecture/Tutorial Hours</b> |
|-----------|---------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                               | <b>7</b>                            |
| 1.1       | Mealy and Moore state machine models.                                                                         | 1                                   |
| 1.2       | State diagram(both moore and mealy),State table                                                               | 1                                   |
| 1.3       | State transition table, Excitation table, State equations.                                                    | 1                                   |
| 1.4       | State reduction – equivalence classes, implication chart method.                                              | 2                                   |
| 1.5       | ASM Chart-Moore and Mealy ASM Chart.                                                                          | 2                                   |
|           | <b>Module 2</b>                                                                                               | <b>10</b>                           |
| 2.1       | Structure of Clocked Synchronous Sequential Networks (CSSN),Design of CSSN                                    | 3                                   |
| 2.2       | Analysis of clocked Synchronous Sequential Networks (CSSN)                                                    | 1                                   |
| 2.3       | Asynchronous Sequential Circuits:Flow table reduction                                                         | 1                                   |
| 2.4       | Races in ASC, State assignment problem and the transition table.Design of ASC                                 | 3                                   |
| 2.5       | Analysis of Asynchronous Sequential Circuits (ASC).                                                           | 2                                   |
|           | <b>Module 3</b>                                                                                               | <b>6</b>                            |
| 3.1       | Hazards – static, dynamic and essential hazards, Design of Hazard free circuits                               | 3                                   |
| 3.2       | Data synchronizers, Mixed operating mode synchronous circuits                                                 | 1                                   |
| 3.3       | Practical issues- clock skew and jitter                                                                       | 1                                   |
| 3.4       | Synchronous and asynchronous inputs – switch bouncing.                                                        | 1                                   |
|           | <b>Module 4</b>                                                                                               | <b>5</b>                            |
| 4.1       | Faults-types,Fault detection-Fault table method                                                               | 1                                   |
| 4.2       | path sensitization method,Boolean difference method                                                           | 1                                   |
| 4.3       | Kohavi algorithm                                                                                              | 2                                   |
| 4.4       | Automatic test pattern generation – Built in Self Test (BIST).                                                | 1                                   |
|           | <b>Module 5</b>                                                                                               | <b>7</b>                            |
| 5.1       | Digital system design options and tradeoffs, Design methodology and technology Overview.                      | 1                                   |
| 5.2       | Programmable logic Devices: ROM, PLA, PAL, CPLD, FPGA Features.                                               | 2                                   |
| 5.3       | Limitations,Architectures and Programming. Implementation of MSI circuits using Programmable logic Devices    | 2                                   |
| 5.4       | FPGAs – Xilinx XC 4000 FPGA family – configurable logic block - input output block, Programmable interconnect | 2                                   |
|           | <b>Total Hours</b>                                                                                            | <b>35 Hours</b>                     |

## CO ASSESSMENT QUESTIONS

### Course Outcome 1 (CO 1):

1. Design a clocked synchronous sequential mealy network to detect the sequence of 1010 with overlapping.
2. Construct an ASM chart for mod6 binary counter

### Course Outcome 2 (CO 2):

1. Explain the shared row state assignment method in asynchronous sequential network with example.
2. Design an asynchronous sequential circuit with two inputs  $x_1$  and  $x_2$  and with one output  $z$ . Whenever  $x_2$  is 1 input  $x_1$  is transferred to  $z$ . When  $x_2$  is 0, the output data do not change for any change in  $x_1$ .

### Course Outcome 3 (CO 3):

1. Examine the possibility of hazard in the AND –OR logic circuit whose Boolean function is given by  $f(A,B,C,D) = m(1,3,6,7,13,15)$ . Show how the hazard can be detected and eliminated.
2. Determine all the static 1 hazards in the Boolean function  $f = yz + wxy' + w'yz'$  and also draw the hazard free circuit.

### Course Outcome 4 (CO 4):

1. Illustrate the fault table method used for effective test set generation for the circuit whose Boolean function is  $z = x_1'x_2 + x_3$ .
2. Find the test vector of all SA0 and SA1 faults of the circuit whose Boolean function is  $f = x_1 x_2 + x_1 x_3'x_4' + x_2 x_4$  by the Kohavi algorithm.

### Course Outcome 5 (CO 5):

1. Explain the input output block architecture in FPGA.
2. What are FPGAs? What are the differences between CPLD and FPGA? What are the advantages of FPGA?

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2026**

**Course Code: B24EC3P14**

**Course Name: DIGITAL SYSTEM DESIGN**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Differentiate between Moore and Mealy model FSM.
2. Explain the timing model of ASM.
3. Differentiate between critical and non critical races in asynchronous sequential network?
4. Define primitive flow table with example.
5. Explain the functionality of mixed mode asynchronous sequential circuit.
6. What is jitter? List the sources of clock jitter.
7. List the limitations of path sensitization method.
8. Explain the properties of Boolean difference method.
9. What is FPGA? What are its advantages of FPGA?
10. Implement the function  $F(a,b,c)=a'b+b'c'+abc$  using PLA.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

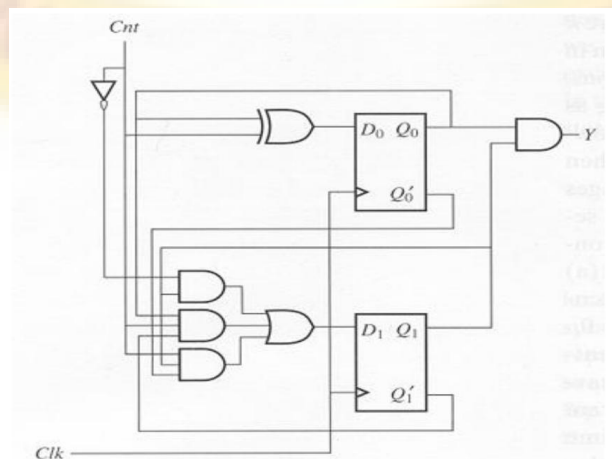
11. a) Draw the Moore and Mealy state diagram of the following flipflops, (i)JK flipflop (7)  
(ii)D flipflop (7)
- b) Draw the ASM chart for a Serial Binary Adder . (7)
12. a) Construct the minimal state table of the following state table given below using equivalence class and implication chart method .Also write the state equations.

| Present state | Next state |   | output   |   |
|---------------|------------|---|----------|---|
|               | Input(x)   |   | Input(x) |   |
|               | 0          | 1 | 0        | 1 |
| A             | A          | B | 0        | 0 |
| B             | D          | C | 0        | 1 |
| C             | F          | E | 0        | 0 |
| D             | D          | F | 0        | 0 |
| E             | B          | G | 0        | 0 |
| F             | G          | C | 0        | 1 |
| G             | A          | F | 0        | 0 |

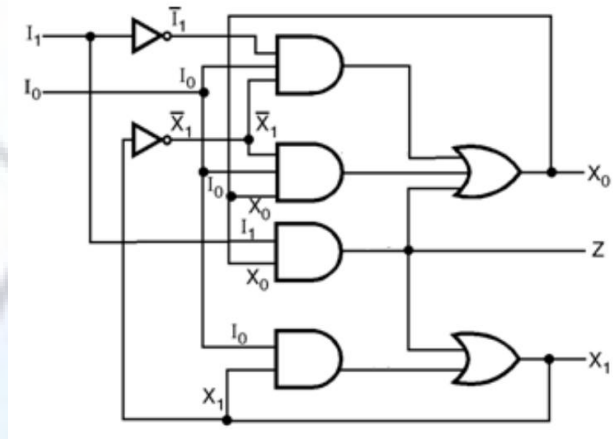
(14)

### Module II

13. a) Design a CSSN using T-FF having a single input line 'y' in which binary symbols 1 and 0 are applied. The network is to produce an output '1' coincident with the first 0 input symbol if it is preceded by exactly two or four 1 input symbols. All other times the output has to remain at 0. Write the proper sample sequence before starting the design. (7)
- b) Analyse the below given CSSN. (7)



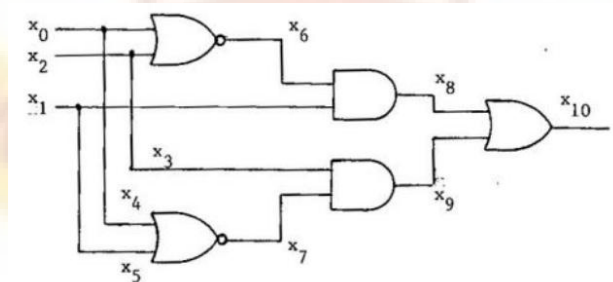
14. a) There are two inputs  $x_1$  and  $x_2$  and single output  $z$ . The inputs  $x_1$  and  $x_2$  never change simultaneously. The output is to be 1 if  $x_1$  was the last input variable to change value. On the hand, the output is to be 0 if  $x_2$  was the last input variable to change value. Design a fundamental mode ASC based on the above behaviour. (7)
- b) Analyse the below given fundamental mode ASC.



(7)

### Module III

15. a) With neat circuit diagrams, differentiate between static and dynamic hazards. (for both 0 and 1 hazards in both) (7)
- b) What do you mean by contact bounce? How do you eliminate contact bounce? Support the explanations with neat circuit diagrams and waveforms named clearly. Also draw the logic diagram for SR latch with the truth table. (7)
16. a) Using path sensitization method, find the test vectors for detecting stuck at faults at  $x_6$  and  $x_9$  for the below given circuit. (7)



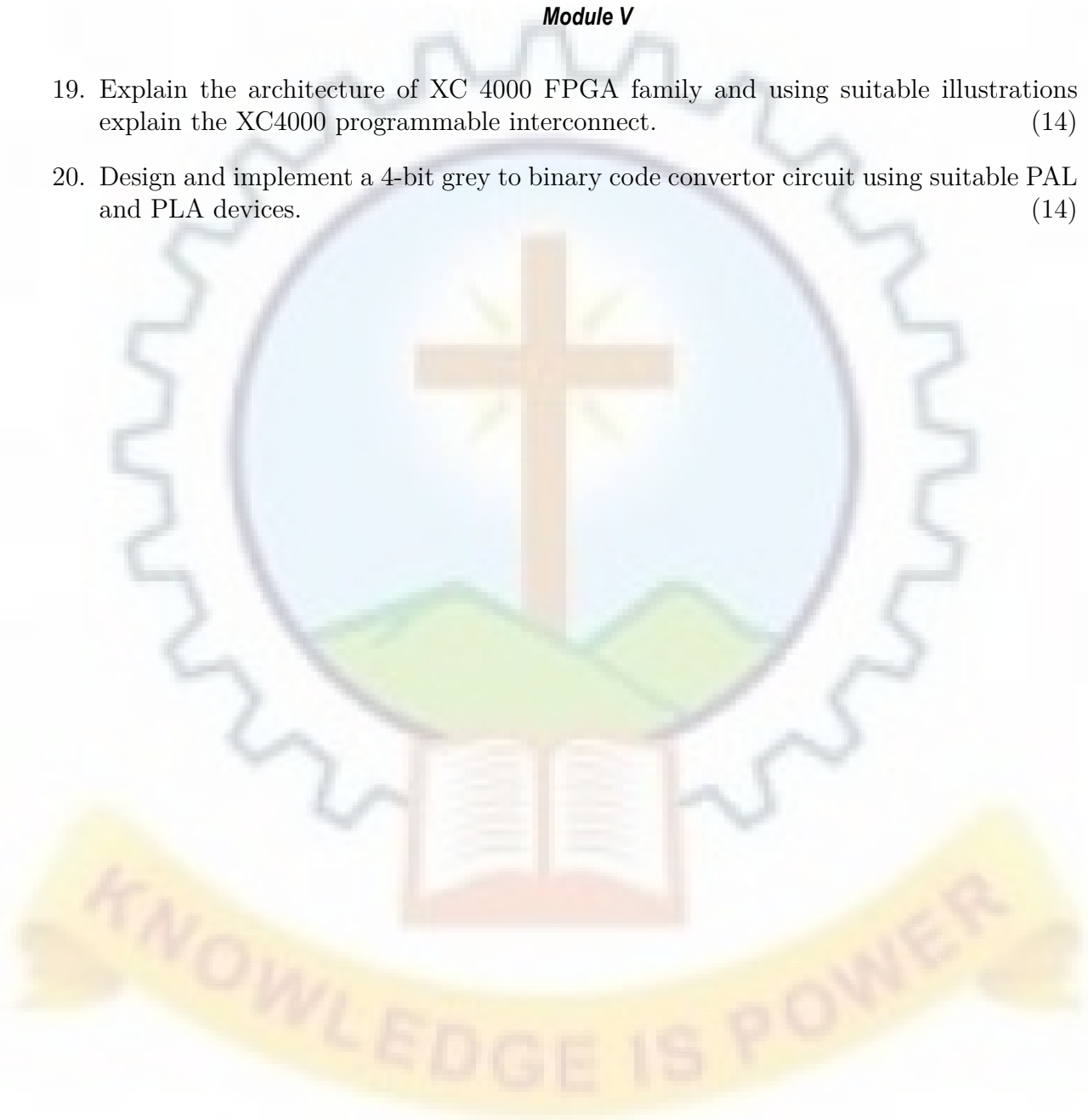
- b) Draw the logic diagram for the expression  $f = a.b'.c + (d'.e')$ . Find the test vectors for detecting the faults at input line  $a$  and  $d$  using Boolean difference method. (Note: ' indicates complement). (7)

### Module IV

17. Find the test vector of all SA0 and SA1 faults of the circuit whose Boolean function is  $f = x_1 x_2 + x_1 x_3' x_4' + x_2 x_4$  by the Kohavi algorithm. (14)
18. A circuit realizes the function  $z = x_1' x_4 + x_2' x_3 + x_1 x_4'$ . Using the Boolean difference method and path sensitization method, find the test vectors for SA0 faults and SA1 faults on the input line  $x_1$  of the circuit. (14)

**Module V**

19. Explain the architecture of XC 4000 FPGA family and using suitable illustrations explain the XC4000 programmable interconnect. (14)
20. Design and implement a 4-bit grey to binary code convertor circuit using suitable PAL and PLA devices. (14)





| <b>B24EC3P15</b> | <b>CHIP<br/>FABRICATION<br/>TECHNOLOGY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF<br/>INTRODUCTION</b> |
|------------------|--------------------------------------------|----------|----------|----------|----------|---------------|---------------------------------|
|                  |                                            | 2        | 1        | 0        | 4        |               |                                 |

**Preamble**

This course provides an in-depth understanding of semiconductor device fabrication processes, wafer processing, lithography, and VLSI chip manufacturing technologies, enabling students to bridge the gap between electronic device theory and practical IC production.

**Prerequisites:** NIL

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                             |
|-------------|-------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Explain the complete sequence of IC fabrication steps. [Understand]                                         |
| <b>CO 2</b> | Describe oxidation, diffusion, and ion implantation mechanisms used in wafer processing. [Understand]       |
| <b>CO 3</b> | Apply photolithography and etching principles for micro-pattern transfer. [Apply]                           |
| <b>CO 4</b> | Understand thin-film deposition and metallization processes for interconnections. [Understand]              |
| <b>CO 5</b> | Analyze process integration, yield, and modern fabrication trends in VLSI technology. [Understand, Analyze] |

**Mapping of Course Outcomes With Program Outcomes**

|             | <b>PO 1</b> | <b>PO 2</b> | <b>PO 3</b> | <b>PO 4</b> | <b>PO 5</b> | <b>PO 6</b> | <b>PO 7</b> | <b>PO 8</b> | <b>PO 9</b> | <b>PO 10</b> | <b>PO 11</b> |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|
| <b>CO 1</b> | 3           | 2           | 1           | 1           | 1           |             |             |             | 2           |              | 2            |
| <b>CO 2</b> | 3           | 3           | 2           | 2           | 2           |             |             |             | 2           |              | 2            |
| <b>CO 3</b> | 3           | 3           | 3           | 2           | 2           |             |             |             | 2           |              | 2            |
| <b>CO 4</b> | 3           | 2           | 2           | 2           | 3           |             |             |             | 2           |              | 2            |
| <b>CO 5</b> | 3           | 3           | 2           | 3           | 3           |             |             |             | 2           |              | 3            |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Semiconductor Materials & Crystal Growth:** Overview of IC fabrication and manufacturing flow, Semiconductor materials: Si, Ge, GaAs, SiC — properties and applications, Crystal growth techniques: Czochralski, Float-zone, Epitaxial growth, Wafer preparation: slicing, lapping, polishing, cleaning, and orientation, Defects in crystals: dislocations, stacking faults, point defects.

### MODULE 2

**Oxidation, Diffusion, and Ion Implantation:** Thermal oxidation: dry and wet oxidation, Deal-Grove model, Diffusion mechanisms: Fick's laws, dopant profiles, junction formation, Ion implantation: process parameters, range, straggle, annealing, Equipment and process control in thermal and implantation systems.

### MODULE 3

**Photolithography and Etching:** Photoresists: positive and negative types, spin coating, baking, exposure, development, Mask design and alignment techniques, Photolithography systems: contact, proximity, projection, Etching techniques: wet etching (HF,  $H_3PO_4$ ), dry etching (plasma, RIE).

### MODULE 4

**Thin Film Deposition and Metallization :** Chemical Vapor Deposition (CVD), Physical Vapor Deposition (PVD), Sputtering and Evaporation methods, Epitaxy and Atomic Layer Deposition (ALD) fundamentals, Metallization: Aluminum and Copper interconnects, Planarization and Chemical Mechanical Polishing.

### MODULE 5

**Process Integration, Yield & Packaging:** CMOS process integration steps: n-well/p-well, twin-tub, SOI technologies, Process simulation and monitoring, Yield, reliability, and defect density analysis, Packaging types: DIP, QFP, BGA, Testing and reliability qualification, Future trends: FinFET, MEMS, and 3D IC fabrication

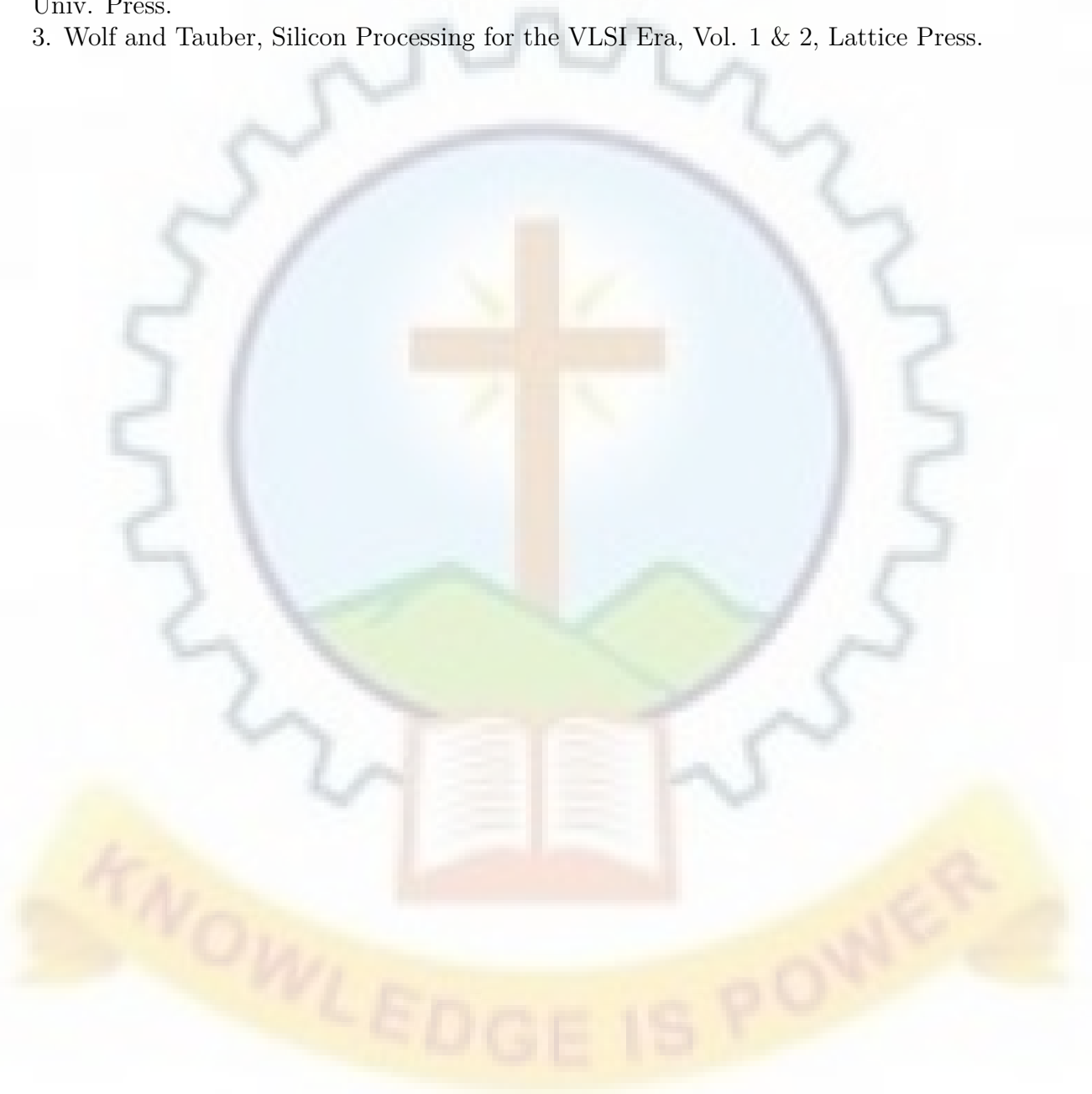
### Text Books

1. S. M. Sze and Kwok K. Ng, Physics of Semiconductor Devices, Wiley.
2. S. M. Sze, VLSI Technology, McGraw-Hill.
3. Plummer, Deal, Griffin, Silicon VLSI Technology: Fundamentals, Practice and Mod-

eling, Prentice Hall.

**Reference Books**

1. Jaeger R. C., Introduction to Microelectronic Fabrication, Pearson.
2. Campbell S. A., The Science and Engineering of Microelectronic Fabrication, Oxford Univ. Press.
3. Wolf and Tauber, Silicon Processing for the VLSI Era, Vol. 1 & 2, Lattice Press.



**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                                        | <b>No of Lecture/Tutorial Hours</b> |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                                                     | <b>7</b>                            |
| 1.1       | Overview of IC fabrication and manufacturing flow, Semiconductor materials: Si, Ge, GaAs, SiC — properties and applications         | 2                                   |
| 1.2       | Crystal growth techniques: Czochralski, Float-zone, epitaxial growth                                                                | 2                                   |
| 1.3       | Wafer preparation: slicing, lapping, polishing, cleaning, and orientation                                                           | 2                                   |
| 1.4       | Defects in crystals: dislocations, stacking faults, point defects                                                                   | 1                                   |
|           | <b>Module 2</b>                                                                                                                     | <b>7</b>                            |
| 2.1       | Thermal oxidation: dry and wet oxidation, Deal-Grove model                                                                          | 2                                   |
| 2.2       | Diffusion mechanisms: Fick's laws, dopant profiles, junction formation                                                              | 2                                   |
| 2.3       | Ion implantation: process parameters, range, straggle, annealing, Equipment and process control in thermal and implantation systems | 3                                   |
|           | <b>Module 3</b>                                                                                                                     | <b>7</b>                            |
| 3.1       | Photoresists: positive and negative types, spin coating, baking, exposure, development, Mask design and alignment techniques        | 3                                   |
| 3.2       | Photolithography systems: contact, proximity, projection                                                                            | 3                                   |
| 3.3       | Etching techniques: wet etching, dry etching                                                                                        | 1                                   |
|           | <b>Module 4</b>                                                                                                                     | <b>7</b>                            |
| 4.1       | Chemical Vapor Deposition (CVD), Physical Vapor Deposition (PVD)                                                                    | 2                                   |
| 4.2       | Sputtering and evaporation method                                                                                                   | 1                                   |
| 4.3       | Epitaxy and Atomic Layer Deposition (ALD) fundamentals                                                                              | 2                                   |
| 4.4       | Metallization: Aluminum and Copper interconnects, Planarization and Chemical Mechanical Polishing                                   | 2                                   |
|           | <b>Module 5</b>                                                                                                                     | <b>8</b>                            |
| 5.1       | CMOS process integration steps: n-well/p-well, twin-tub                                                                             | 2                                   |
| 5.2       | SOI technologies, Process simulation and monitoring, Yield, reliability, and defect density analysis                                | 2                                   |
| 5.3       | Packaging types: DIP, QFP, BGA, Testing and reliability qualification                                                               | 2                                   |
| 5.4       | Future trends: FinFET, MEMS, and 3D IC fabrication                                                                                  | 2                                   |
|           | <b>Total Hours</b>                                                                                                                  | <b>36 Hours</b>                     |

## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1):**

1. Explain the complete sequence of IC fabrication steps.
  - (a) Explain the basic IC fabrication flow with a neat diagram.
  - (b) Explain in detail about crystal growth techniques.
  - (c) Write a note on wafer preparation steps in fabrication.

### **Course Outcome 2 (CO 2):**

1. Describe oxidation, diffusion, and ion implantation mechanisms used in wafer processing.
  - (a) Explain dry and wet thermal oxidation processes.
  - (b) State Fick's laws of diffusion and their role in doping.
  - (c) What is ion implantation? Explain range and straggle.

### **Course Outcome 3 (CO 3):**

1. Apply photolithography and etching principles for micro-pattern transfer.
  - (a) Explain the photolithography process with steps involved.?
  - (b) Differentiate between wet etching and dry etching.
  - (c) Apply lithography principles to pattern a MOS gate structure.?

### **Course Outcome 4 (CO 4):**

1. Understand thin-film deposition and metallization processes for interconnections.
  - (a) Explain CVD and PVD techniques used for thin-film deposition.
  - (b) What is sputtering? Explain its working principle.
  - (c) Write a short note on CMP in multilevel metallization.

### **Course Outcome 5 (CO 5):**



1. Analyze process integration, yield, and modern fabrication trends in VLSI technology.
  - (a) Explain CMOS n-well or p-well process integration.
  - (b) What is yield? Explain defect density and reliability concerns in ICs.
  - (c) Compare FinFET and MEMS technologies.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 2**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, NOVEMBER 2026**

**Course Code: B24EC3P15**

**Course Name: CHIP FABRICATION TECHNOLOGY**

Max. Marks: 100

Duration: 3 hours

**PART A**

*Answer all questions. Each question carries 3 marks*

1. List any two properties of Silicon that make it suitable for IC fabrication.
2. What is the difference between Czochralski and Float-zone crystal growth techniques?
3. Define Dry and Wet Oxidation.
4. State Fick's First Law of Diffusion.
5. What is photoresist? Differentiate between positive and negative resists.?
6. Define Critical Dimension (CD) in lithography.?
7. What is PVD? Give one example.
8. What is the need for CMP in IC fabrication?
9. Define yield and defect density in semiconductor manufacturing.?
10. Mention any two advantages of FinFET over planar MOSFET.?

**PART B**

*Answer any one question from each module. Each question carries 14 marks*

**Module I**

11. a) Explain the IC fabrication manufacturing flow with neat diagram. (7)  
b) Describe wafer preparation steps: slicing, polishing, cleaning and orientation.? (7)

12. a) Explain crystal growth methods: Czochralski and Epitaxial growth? (7)  
b) Discuss crystal defects such as point defects, dislocations, and stacking faults? (7)

**Module II**

13. a) Explain the thermal oxidation process and the Deal-Grove model.? (7)  
b) Describe Fick's laws of diffusion and dopant profiles.? (7)
14. a) Explain the ion implantation process with process parameters: dose, energy, range and straggle.? (7)  
b) Discuss post-implant annealing and dopant activation.? (7)

**Module III**

15. Explain the photolithography process sequence and mask alignment with neat sketches.? (14)
16. Explain wet etching and dry etching (Plasma & RIE) highlighting etch rate, anisotropy and selectivity.? (14)

**Module IV**

17. Explain CVD and PVD techniques used for thin-film deposition with examples.? (14)
18. Discuss copper metallization and the need for chemical mechanical polishing method? (14)

**Module V**

19. Explain the CMOS process integration steps for n-well technology with neat diagram.? (14)
20. Explain in detail about packaging types and 3D IC fabrication.? (14)

| B24EC3L07 | LINEAR<br>INTEGRATED<br>CIRCUITS LAB | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|--------------------------------------|---|---|---|---|--------|-------------------------|
|           |                                      | 0 | 0 | 3 | 2 |        |                         |

**Preamble**

This lab course is designed to help students familiarize with Linear Integrated Circuits, including their design and implementation in various application circuits. It also aims to provide hands-on experience with the simulation of fundamental Linear Integrated Circuits.

**Prerequisite**

B24EC2T06 : LINEAR INTEGRATED CIRCUITS

**Course Outcomes**

After the completion of the course the student will be able to

|             |                                                                                                |
|-------------|------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Familiarize the basic parameters of an Analog IC from datasheet as well as experiment. [Apply] |
| <b>CO 2</b> | Design and implement application circuits using Analog ICs. [Apply]                            |
| <b>CO 3</b> | Design and implement application circuits using 555 timer IC. [Apply]                          |
| <b>CO 4</b> | Design and simulate the application circuits with Analog ICs using simulation tools. [Apply]   |
| <b>CO 5</b> | Function effectively as an individual and in a team to accomplish the given task. [Apply]      |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| <b>CO 1</b> | 3   | 3   | 1   | 1   | 3   |     | 1   | 3   | 3   | 1    | 1    |
| <b>CO 2</b> | 3   | 3   | 1   | 1   | 3   |     | 1   | 3   | 3   |      | 1    |
| <b>CO 3</b> | 3   | 3   | 1   | 1   | 3   |     | 1   | 3   | 3   |      | 1    |
| <b>CO 4</b> | 3   | 3   | 1   | 1   | 3   |     | 1   | 3   | 3   |      | 1    |
| <b>CO 5</b> | 3   | 3   | 1   | 1   | 3   |     | 1   | 3   | 3   | 1    | 1    |

**Mark Distribution****Continuous Internal Evaluation Pattern**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hour       |

|                       |          |
|-----------------------|----------|
| Attendance            | 10 marks |
| Continuous Assessment | 20 marks |
| Internal Test         | 20 marks |

### End semester Examination pattern

|                                |          |
|--------------------------------|----------|
| Preliminary Work               | 30 marks |
| Performance and Implementation | 20 marks |
| Result and Inference           | 30 marks |
| Viva                           | 20 marks |

## SYLLABUS

### LIST OF EXPERIMENTS

**PART-A: Fundamentals of operational amplifiers and basic circuits. (Minimum seven experiments are to be done.)**

|    |                                                                                                                                         |
|----|-----------------------------------------------------------------------------------------------------------------------------------------|
| 1  | Familiarization of Operational amplifiers - Inverting and Non inverting amplifiers, frequency response, Adder, Integrator, Comparators. |
| 2  | Measurement of Op-Amp parameters.                                                                                                       |
| 3  | Difference Amplifier and Instrumentation amplifier.                                                                                     |
| 4  | Schmitt trigger circuit using Op-Amps.                                                                                                  |
| 5  | Astable and Monostable multivibrator using Op-Amps.                                                                                     |
| 6  | Waveform generators using Op-Amps - Triangular and saw tooth.                                                                           |
| 7  | RC Phase shift Oscillator.                                                                                                              |
| 8  | Active second order filters using Op-Amp (LPF, HPF, BPF and BSF).                                                                       |
| 9  | Notch filters to eliminate the 50Hz power line frequency.                                                                               |
| 10 | Precision rectifiers using Op-Amp.                                                                                                      |

**PART-B: Application circuits of 555 Timer/565 PLL/ Regulator(IC 723) ICs. (Minimum three experiments are to be done.)**

|   |                                                                                                                    |
|---|--------------------------------------------------------------------------------------------------------------------|
| 1 | Astable and Monostable multivibrator using Timer IC NE555.                                                         |
| 2 | DC power supply using IC 723: Low voltage and high voltage configurations, Short circuit and Fold-back protection. |
| 3 | A/D converters- flash type.                                                                                        |
| 4 | D/A Converters - R-2R ladder circuit.                                                                              |
| 5 | Study of PLL IC: free running frequency lock range capture range.                                                  |

**PART-C: Simulation experiments.** (The experiments shall be conducted using SPICE.)

|          |                                               |
|----------|-----------------------------------------------|
| <b>1</b> | Simulation of any three circuits from Part-A. |
| <b>2</b> | Simulation of any one circuit from Part-B.    |

### Reference Books

1. Robert Boylestad and L Nashelsky, Electronic Devices and Circuit Theory, Pearson, 2015.
2. Op-Amp and Linear Integrated Circuits, Ramakant A Gayakwad, PHI, 2000.
3. D. Roy Choudhary, Shail B Jain, Linear Integrated Circuits, New Age International Publishers.
4. M. H. Rashid, Introduction to Pspice Using Orcad for Circuits and Electronics, Pearson.



| B24EC3L08 | CONTROL SYSTEMS LAB | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|---------------------|---|---|---|---|--------|----------------------|
|           |                     | 0 | 0 | 3 | 2 | 2      | 2024                 |

### Preamble

This laboratory course provides practical experience in control systems analysis and design using MATLAB/Octave, covering key topics such as matrix operations, transfer function derivation, system response analysis, and controller simulations.

### Prerequisite

B24EC2T05: SIGNALS AND SYSTEMS

### Course Outcomes

After the completion of the course the student will be able to

|      |                                                                                                                                                                                                        |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | To familiarize students with the use of MATLAB/Octave toolboxes, focusing on the Control Systems Toolbox for system analysis and design.[Understand]                                                   |
| CO 2 | To enable students to perform basic matrix operations, such as calculating the transpose and inverse of matrices. [Apply]                                                                              |
| CO 3 | To teach students how to analyze transfer functions by plotting pole-zero configurations and deriving transfer functions from block diagrams. [Apply]                                                  |
| CO 4 | To develop students' skills in time-domain and frequency-domain analysis, including plotting unit step responses, root locus, Bode, and Nyquist plots, and determining system characteristics. [Apply] |
| CO 5 | To provide hands-on experience in simulating and experimentally verifying the performance of various controllers (P, PD, PI, and PID) for control system applications. [Apply]                         |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    |      | 2    | 3    |      |      |      | 2    | 2     | 2     |
| CO 2 | 3    | 3    |      | 2    | 3    |      |      |      | 2    | 2     | 2     |
| CO 3 | 3    | 3    | 2    | 2    | 3    |      |      |      | 2    | 2     | 2     |
| CO 4 | 3    | 3    | 2    | 3    | 3    |      |      |      | 2    | 2     | 2     |
| CO 5 | 3    | 3    | 3    | 3    | 3    |      |      |      | 3    | 3     | 2     |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hour       |

### Continuous Internal Evaluation Pattern

|                       |          |
|-----------------------|----------|
| Attendance            | 10 marks |
| Continuous Assessment | 20 marks |
| Internal Test         | 20 marks |

### End semester Examination pattern

|                                |          |
|--------------------------------|----------|
| Preliminary Work               | 30 marks |
| Performance and Implementation | 20 marks |
| Result and Inference           | 30 marks |
| Viva                           | 20 marks |

## SYLLABUS

### LIST OF EXPERIMENTS

|   |                                                                                                                              |
|---|------------------------------------------------------------------------------------------------------------------------------|
| 1 | Introduction to various toolboxes in MATLAB/Octave, with a focus on the Control Systems Toolbox.                             |
| 2 | Calculate the transpose and inverse of a given matrix.                                                                       |
| 3 | Plot the pole-zero configuration in the s-plane for the specified transfer function.                                         |
| 4 | Derive the transfer function for a closed-loop system represented by a block diagram.                                        |
| 5 | Plot the unit step response of a given transfer function and calculate delay time, rise time, peak time, and peak overshoot. |
| 6 | Determine the time response of a system subjected to an arbitrary input.                                                     |
| 7 | Plot the root locus of a given transfer function and identify the closed-loop poles for different values of k.               |

|           |                                                                                                                                                                             |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>8</b>  | Calculate the steady-state error for a given transfer function.                                                                                                             |
| <b>9</b>  | Plot the Bode plot of a given transfer function and assess the relative stability by measuring the gain and phase margins.                                                  |
| <b>10</b> | Plot the Nyquist plot for a given transfer function and analyze the closed-loop stability, as well as determine relative stability by measuring the gain and phase margins. |
| <b>11</b> | Simulate and experimentally verify the performance of P, PD, PI, and PID controllers.                                                                                       |

### Reference Books

1. Moore, H. (2016). MATLAB for Engineers. Pearson.
2. Dorf, R. H., & Bishop, R. H. (2011). MATLAB for Control System Engineers. Pearson Prentice Hall.
3. Nise, N. S. (2015). Control Systems Engineering (7th ed.). Wiley.
4. Hahn, B., & Valentine, D. T. (2009). MATLAB for Control System Design. Prentice Hall.
5. Attaway, S. (2013). Practical MATLAB for Engineers (3rd ed.). Elsevier.

| B24ECM51 | EMBEDDED<br>SYSTEM DESIGN<br>(Minor) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|----------|--------------------------------------|---|---|---|---|--------|-------------------------|
|          |                                      | 3 | 1 | 0 | 5 |        |                         |

### Preamble

This course introduces the fundamentals of embedded systems, covering processor architectures, real-time programming, and peripheral interfacing. Students will learn to develop efficient applications using Embedded C and assembly language, with emphasis on system-level design, interrupt handling, and bus architectures. The course prepares students to design reliable and optimized embedded solutions for real-world applications.

### Prerequisites

B24ECM31 : ELECTRONIC CIRCUITS

B24ECM41 : MICROCONTROLLERS

### Course Outcomes

After the completion of the course, the student will be able to:

|      |                                                                                                                                                                                                          |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Understand and gain the basic idea about the embedded system. [Understand]                                                                                                                               |
| CO 2 | Able to gain architectural level knowledge about the system and hence to program an embedded system. [Apply]                                                                                             |
| CO 3 | Apply the knowledge for solving the real life problems with the help of an embedded system. [Apply]                                                                                                      |
| CO 4 | Students will be able to explain the architecture and programmer's model of the ARM processor and instruction execution mechanisms of ARM-based systems. [Understand, Apply]                             |
| CO 5 | Students will be able to explain ARM architectural support for high-level languages, use the Thumb instruction set effectively, and describe the role of AMBA in system development. [Understand, Apply] |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| CO 2 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| CO 3 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| CO 4 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| CO 5 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 10                                 |
| Understand       | 40                    | 40              | 20                                 |
| Apply            | 40                    | 40              | 70                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Introduction to Embedded systems:** Complex Systems and Microprocessors: Characteristics of embedded computing Applications ,Application of Microprocessors,Challenges in Embedded Computing Systems,Characteristics and quality attributes of an embedded system ,performance in Embedded Computing.The embedded System Design Process:Requirements ,Specification,Architecture Design ,Designing Hardware and Software Components and System Integration .Embedded product Development Cycle(EDLC):Different Phases of EDLC and EDLC Models.

### MODULE 2

**Embedded System interfacing and peripherals:** Communication Devices:Serial Communication Standard and Devices-UART,HDLC,SPI.Serial Bus Protocols:-I2C Bus,CAN Bus,USB Bus,Parallel communication standards-ISA,PCI and PCI-X Bus.Memory: Memory Devices and Systems: ROM -Flash,EEPROM: RAM-SRAM,DRAM,Cache Memory,I/O Device: Interrupt Sources,recognizing an interrupt ,ISR-Device drivers for handling ISR ,Interrupt latency.

### MODULE 3

**Embedded Programming:** Programming languages: Assembly Languages, High-level languages, Embedded C, Object-oriented programming, C++, JAVA. Embedded C programming: Keywords and Identifiers, Data Types, Storage Class, Operators, branching, looping, arrays, pointers, characters, strings, functions, function pointers.

### MODULE 4

**ARM Processor fundamentals** ARM Processor architecture: The Acorn RISC Machine - Architectural inheritance, The ARM programmer's model. ARM Assembly Language Programming: Data processing instructions, Data transfer instructions, Control flow instructions, writing simple assembly language programs. ARM Organization and Implementation: 3-stage pipeline ARM organization, 5-stage pipeline ARM organization,ARM instruction execution.

### MODULE 5

**ARM Programming:** Architectural Support for High Level Languages :-Data types,



Floating-point data types, The ARM floating-point architecture, Expressions, Conditional statements, Loops, Functions and procedures, Use of memory, Run-time environment. The Thumb Instruction Set :-The Thumb bit in the CPSR, The Thumb programmer's model, Thumb branch instructions, Thumb software interrupt instruction, Thumb data processing instructions, Thumb single register data transfer instructions, Thumb multiple register data transfer instructions, Thumb breakpoint instruction. Architectural Support for System Development:- The Advanced Microcontroller Bus Architecture (AMBA).

### **Text Books**

1. Raj Kamal, Embedded Systems Architecture, Programming and Design, TMH, 2003
2. K.V. Shibu, Introduction to Embedded Systems, 2e, McGraw Hill Education India, 2016.
3. Wayne Wolf, Computers as Components: Principles of Embedded Computing System Design, Morgan Kaufman Publishers - Elsevier 3ed, 2008
4. Steve Furber, ARM system-on-chip architecture, Addison Wesley, Second Edition, 2000
5. David E. Simon, An Embedded Software Primer, Pearson Education Asia, First Indian Reprint 2000.
6. Steve Heath, Embedded Systems Design, Newnes - Elsevier 2ed, 2002

## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                                    | No of Lecture/Tutorial Hours |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                                          | <b>8</b>                     |
| 1.1 | Introduction to Embedded systems.Complex Systems and Microprocessors:Characteristics of embedded computing Applications .                                                | 1                            |
| 1.2 | Application of Microprocessors,Challenges in Embedded Computing Systems,Characteristics and quality attributes of an embedded system ,performance in Embedded Computing. | 2                            |
| 1.3 | The embedded System Design Process:Requirements ,Specification,Architecture Design ,Designing Hardware and Software Components and System Integration.                   | 2                            |
| 1.4 | Embedded product Development Cycle(EDLC):Different Phases of EDLC and EDLC Models.                                                                                       | 3                            |
|     | <b>Module 2</b>                                                                                                                                                          | <b>9</b>                     |
| 2.1 | Embedded System interfacing and peripherals: Communication Devices:Serial Communication Standard and Devices-UART,HDLC,SPI.                                              | 2                            |
| 2.2 | Serial Bus Protocols:-I2C Bus,CAN Bus,USB Bus,Parallel communication standards-ISA,PCI and PCI-X Bus.                                                                    | 3                            |
| 2.3 | Memory: Memory Devices and Systems: ROM - Flash,EEPROM: RAM-SRAM,DRAM,Cache Memory.                                                                                      | 2                            |
| 2.4 | I/O Device: Interrupt Sources,recognizing an interrupt ,ISR-Device drivers for handling ISR ,Interrupt latency.                                                          | 2                            |
|     | <b>Module 3</b>                                                                                                                                                          | <b>11</b>                    |
| 3.1 | Embedded Programming Programming languages: Assembly Languages, High-level languages, Embedded C, Object-oriented programming, C++, JAVA.                                | 2                            |
| 3.2 | Embedded C programming: Keywords and Identifiers, Data Types, Storage Class.                                                                                             | 4                            |
| 3.3 | Operators, branching, looping, arrays, pointers, characters, strings,                                                                                                    | 3                            |
| 3.4 | functions, function pointers.                                                                                                                                            | 2                            |
|     | <b>Module 4</b>                                                                                                                                                          | <b>7</b>                     |
| 4.1 | ARM Processor fundamentals ARM Processor architecture: The Acorn RISC Machine - Architectural inheritance, The ARM programmer's model.                                   | 2                            |
| 4.2 | ARM Assembly Language Programming: Data processing instructions, Data transfer instructions, Control flow instructions, writing simple assembly language programs.       | 3                            |

|     |                                                                                                                                                                                                                                                                                                                               |                 |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 4.3 | ARM Organization and Implementation: 3-stage pipeline ARM organization, 5-stage pipeline ARM organization, ARM instruction execution.                                                                                                                                                                                         | 2               |
|     | <b>Module 5</b>                                                                                                                                                                                                                                                                                                               | <b>10</b>       |
| 5.1 | ARM Programming: Architectural Support for High Level Languages :-Data types, Floating-point data types, The ARM floating-point architecture, Expressions, Conditional statements, Loops, Functions and procedures, Use of memory, Run-time environment.                                                                      | 4               |
| 5.2 | The Thumb Instruction Set :-The Thumb bit in the CPSR, The Thumb programmer's model, Thumb branch instructions, Thumb software interrupt instruction, Thumb data processing instructions, Thumb single register data transfer instructions, Thumb multiple register data transfer instructions, Thumb breakpoint instruction. | 4               |
| 5.3 | Architectural Support for System Development:- The Advanced Microcontroller Bus Architecture (AMBA).                                                                                                                                                                                                                          | 2               |
|     | <b>Total Hours</b>                                                                                                                                                                                                                                                                                                            | <b>45 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO1):

1. Give the challenges of embedded computing.
2. What are the phases of EDLC?.

#### Course Outcome 2 (CO2):

1. Compare and contrast the PCI bus and PCI-X bus.
2. How the ROM memories are classified? Explain.
3. How the peripheral devices are connected with processors?

#### Course Outcome 3 (CO 3):

1. Write an embedded C program for sorting 64 numbers stored in memory locations and find the smallest and largest number.
2. How the functions are called by using pointers in embedded 'C'? Discuss with the help of examples.

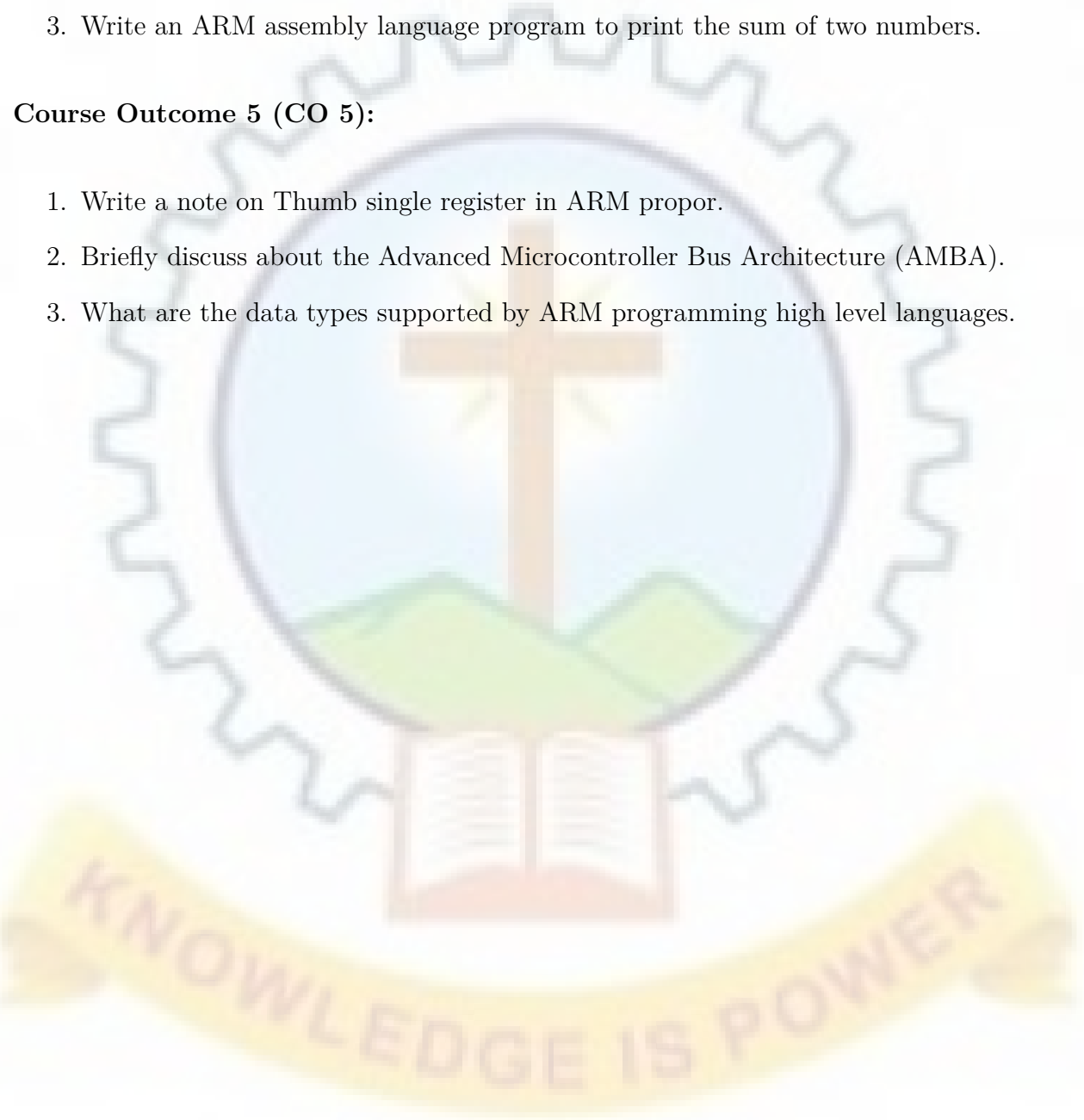
3. Give the features of Object Oriented Programming.

**Course Outcome 4 (CO 4):**

1. Give the architecture of the ARM processor and explain the registres.
2. Explain the pipelined architecture of ARM processor.
3. Write an ARM assembly language program to print the sum of two numbers.

**Course Outcome 5 (CO 5):**

1. Write a note on Thumb single register in ARM propor.
2. Briefly discuss about the Advanced Microcontroller Bus Architecture (AMBA).
3. What are the data types supported by ARM programming high level languages.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2026**

**Course Code: B24ECM51**

**Course Name: EMBEDDED SYSTEM DESIGN**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define an embedded system
2. Write any three challenges of embedded system design
3. Explain how an RS232 device is interfaced to a processor
4. What is interrupt latency?
5. What are the differences between assembly level language and high level language?
6. What is a function pointer? Give an example of its declaration?
7. Write the contents of CPSR register of ARM processor and their use.
8. Draw the five stage pipeline architecture of ARM processor
9. What is the use of thumb instruction set in ARM processor?
10. Write a note on ARM memory interface.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) What are the characteristics of an embedded system? Explain. (7)  
b) Explain the different phases of EDLC. (7)
12. a) Write different steps involved in the embedded system design process. (7)  
b) Explain EDLC in Detail. (7)

**Module II**

13. a) What is serial and parallel port communication? Explain with the help of necessary diagrams. (7)  
b) What is interrupt? How interrupts are handled in a processor? Explain ISR. (7)
14. a) With the help of a diagram show how ROM and RAM are interfaced to a processor. Explain the read/write processes.. (7)  
b) Explain the role of device drivers in interrupt handling. Describe how they interact with hardware and the operating system. (7)

**Module III**

15. a) What are the advantages and disadvantage of object oriented programming like C++ and Java. (7)  
b) Write an embedded C program for adding 64 numbers stored in memory locations and find the average of the same. (7)
16. a) Describe arrays and pointers in Embedded C. with example. (7)  
b) Write an embedded C program to perform addition, subtraction, multiplication and division operations of 2 numbers stored in specific memory locations using a mode control. (7)

**Module IV**

17. a) Write a note on ARM processor architecture and its registers (7)  
b) Write a note on data processing and data transfer instructions with the help of examples. (7)
18. a) What is pipelined architecture? Explain how an ARM instruction is executed in a five stage pipeline processor with the help of an example (8)  
b) Write an ARM assembly language program to print a text string to "Hello World" (6)

**Module V**

19. a) Explain ARM floating point architecture and discuss how floating point numbers are handled (7)  
b) Write a note on Thumb single register and multiple register data transfer instructions with the help of examples (7)
20. a) What is Thumb instruction set? Why it is used? Explain Thumb programmers model (7)  
b) Draw the block diagram of AMBA architecture. What are the different types of buses used in this architecture? (7)



| <b>B24ECM52</b> | <b>COMMUNICATION<br/>SYSTEMS<br/>(Minor)</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF<br/>INTRODUCTION</b> |
|-----------------|----------------------------------------------|----------|----------|----------|----------|---------------|---------------------------------|
|                 |                                              | 3        | 1        | 0        | 5        |               |                                 |

**Preamble**

This course introduces the fundamental concepts and technologies used in modern communication systems. It provides awareness on optical communication, RADAR, satellite communication, cellular networks, and computer communication protocols, helping students understand the components, principles, and practical applications of communication systems.

**Prerequisites:** NIL

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                           |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the components required for an Optical Communication Systems and design a transceiver system according to the requirement. [Understand, Apply] |
| <b>CO 2</b> | Discuss the principle involved in RADAR and Navigation for suitable applications.[Understand, Apply]                                                      |
| <b>CO 3</b> | Explain the concept of Cellular Communication networks. [Understand]                                                                                      |
| <b>CO 4</b> | Outline the principles of Satellite communication systems [Understand]                                                                                    |
| <b>CO 5</b> | Discuss the role of different layers in TCP/IP protocol stack in communication networks. [Apply]                                                          |

**Mapping of Course Outcomes With Program Outcomes**

|             | <b>PO 1</b> | <b>PO 2</b> | <b>PO 3</b> | <b>PO 4</b> | <b>PO 5</b> | <b>PO 6</b> | <b>PO 7</b> | <b>PO 8</b> | <b>PO 9</b> | <b>PO 10</b> | <b>PO 11</b> |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|
| <b>CO 1</b> | 3           | 2           | 3           | 2           | 3           | 1           |             | 1           | 2           | 1            | 2            |
| <b>CO 2</b> | 3           | 3           | 2           | 3           | 2           | 1           |             |             | 2           |              | 2            |
| <b>CO 3</b> | 3           | 2           | 2           | 1           | 2           | 1           |             | 1           | 2           |              | 1            |
| <b>CO 4</b> | 3           | 2           | 2           | 1           | 2           | 2           | 1           |             | 2           | 1            | 1            |
| <b>CO 5</b> | 3           | 3           | 3           | 3           | 3           | 1           |             | 1           | 3           | 2            | 3            |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 10                    | 10                 | 10                                    |
| Understand       | 20                    | 20                 | 40                                    |
| Apply            | 20                    | 20                 | 50                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Optical Communication:** Block diagram, Advantages of optical fiber communication systems, Principles of light transmission in a fiber using ray theory, Single-mode fibers, Multimode fibers, Step-index fibers, Graded-index fibers (basic concepts only), Attenuation in optical fibers – absorption losses, scattering losses, bending losses, core and cladding losses.

**Optical transmitters:** LED and semiconductor laser, characteristics, Transmitter design.

**Optical receivers:** Common photo detectors. Receiver design

### MODULE 2

**Radar and Navigation:** Basic Radar System– Applications, Radar range equation (qualitative treatment only), factors influencing maximum range, Basic pulsed radar system – block diagram, display methods – A-scope, PPI display, Instrument landing system, Ground controlled approach system.

### MODULE 3

**Cellular Communication:** Cellular Communication, Hand off, Frequency reuse, Principles of multicarrier communication, Multiple access techniques, CDMA Systems: general aspects of CDMA cellular systems, IS-95 standard, Downlink and Uplink, GSM standard and service aspects – GSM architecture, Evolution to third generation systems, WCDMA and CDMA-2000 standards, 4G, 5G

### MODULE 4

**Satellite Communication:** Basic concept of satellite communication, Kepler's law, Satellite orbits, Geosynchronous satellites, Active and Passive satellite, Block diagram for satellite uplink and downlink, Transponder and earth station receiver

### MODULE 5

**Data Communication and Networks:** Study of OSI and TCP/IP protocol suit: The model, functions of each layer, TCP/IP Protocol suites. Wireless Ad Hoc Networks: Issues and Challenges, Wireless Sensor Networks: Architecture, Data dissemination, Data gathering, MAC Protocols, Location discovery, Quality of a sensor network 6LoWPAN

### Text Books

1. Electronic communication system fundamentals Wayne Tomasi, Pearson Education.

2. Data Communication and Networking by Behrouz A. Forouzan (Fourth Edition), Tata McGraw Hill

**Reference Books**

1. Wireless communication principles and practice T S Rappaport, Pearson Education.
2. G. E. Keiser – Optical Fibre Communication – Mc Graw Hill Publication.
3. D. C. Agarwal – Satellite Communication – Khanna Publications.
4. Jochen Schiller - Mobile Communications- Pearson Education
5. Siva ram Murthy, B S Manoj- Ad Hoc Wireless Networks – Printice Hall.



**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                             | <b>No of Lecture/Tutorial Hours</b> |
|-----------|--------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                                          | <b>8</b>                            |
| 1.1       | Optical Communication System – Block Diagram – Advantages Of Optical Fiber Communication Systems                         | 1                                   |
| 1.2       | Principles Of Light Transmission In A Fiber Using Ray Theory                                                             | 1                                   |
| 1.3       | Single Mode Fibers, Multimode Fibers – Step Index Fibers, Graded Index Fibers (Basic Concepts Only)                      | 1                                   |
| 1.4       | Attenuation In Optical Fibers – Absorption Losses, Scattering Losses, Bending Losses, Core And Cladding Losses.          | 1                                   |
| 1.5       | Optical transmitters: LED and semiconductor LASER, characteristics, transmitter design.                                  | 2                                   |
| 1.6       | Optical receivers: Common photo detectors. Receiver design                                                               | 2                                   |
|           | <b>Module 2</b>                                                                                                          | <b>7</b>                            |
| 2.1       | Basic Radar System– Applications – Radar Range Equation (Qualitative Treatment Only) – Factors Influencing Maximum Range | 2                                   |
| 2.2       | Basic Pulsed Radar System – Block Diagram – Display Methods- A - Scope, PPI Display                                      | 2                                   |
| 2.3       | Instrument Landing System – Ground Controlled Approach System.                                                           | 3                                   |
|           | <b>Module 3</b>                                                                                                          | <b>12</b>                           |
| 3.1       | Cellular Communication, Hand off, Frequency Reuse,                                                                       | 2                                   |
| 3.2       | Principles of Multicarrier communication, Multiple Access techniques                                                     | 2                                   |
| 3.3       | CDMA Systems: General aspects of CDMA cellular systems, IS-95 standard, Downlink and uplink                              | 2                                   |
| 3.4       | GSM standard and service aspects – GSM architecture                                                                      | 2                                   |
| 3.5       | Evolution to Third Generation systems, WCDMA and CDMA-2000 standards                                                     | 2                                   |
| 3.6       | 4G, 5G                                                                                                                   | 2                                   |
|           | <b>Module 4</b>                                                                                                          | <b>7</b>                            |
| 4.1       | Basic concept of satellite communication, Kepler's law,                                                                  | 2                                   |
| 4.2       | Satellite orbits, Geosynchronous satellites                                                                              | 1                                   |
| 4.3       | Active and Passive satellite, Block diagram for Satellite uplink, Transponder and earth station receiver                 | 4                                   |
|           | <b>Module 5</b>                                                                                                          | <b>11</b>                           |
| 5.1       | Study of OSI and TCP/IP protocol suit: The Model, Functions of each layer, TCP/IP Protocol Suites.                       | 4                                   |

|     |                                                                              |                 |
|-----|------------------------------------------------------------------------------|-----------------|
| 5.2 | Issues and challenges in Wireless Ad Hoc Networks, Vehicular Ad Hoc Networks | 2               |
| 5.3 | Wireless Sensor Networks: Architecture, Data dissemination, Data gathering   | 3               |
| 5.4 | MAC Protocols, Location discovery, Quality of a sensor network, 6LoWPAN      | 2               |
|     | <b>Total Hours</b>                                                           | <b>45 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the components required for an Optical Communication Systems?
  - (a) Explain the block diagram for Optical Communication Systems
  - (b) Distinguish between step index and graded index fiber
  - (c) Explain various attenuations occurring in optical fiber

#### Course Outcome 2 (CO 2):

1. Discuss the principle involved in RADAR and Navigation
  - (a) Explain Radar range equation and how the range of a radar system is increased?
  - (b) Explain the block diagram for pulsed radar system
  - (c) Explain Instrument landing system

#### Course Outcome 3 (CO 3):

1. Explain the concept and subsystems for Cellular Communication networks
  - (a) What is frequency reuse?
  - (b) Explain the principle of multicarrier communication
  - (c) Explain GSM architecture

#### Course Outcome 4 (CO 4):

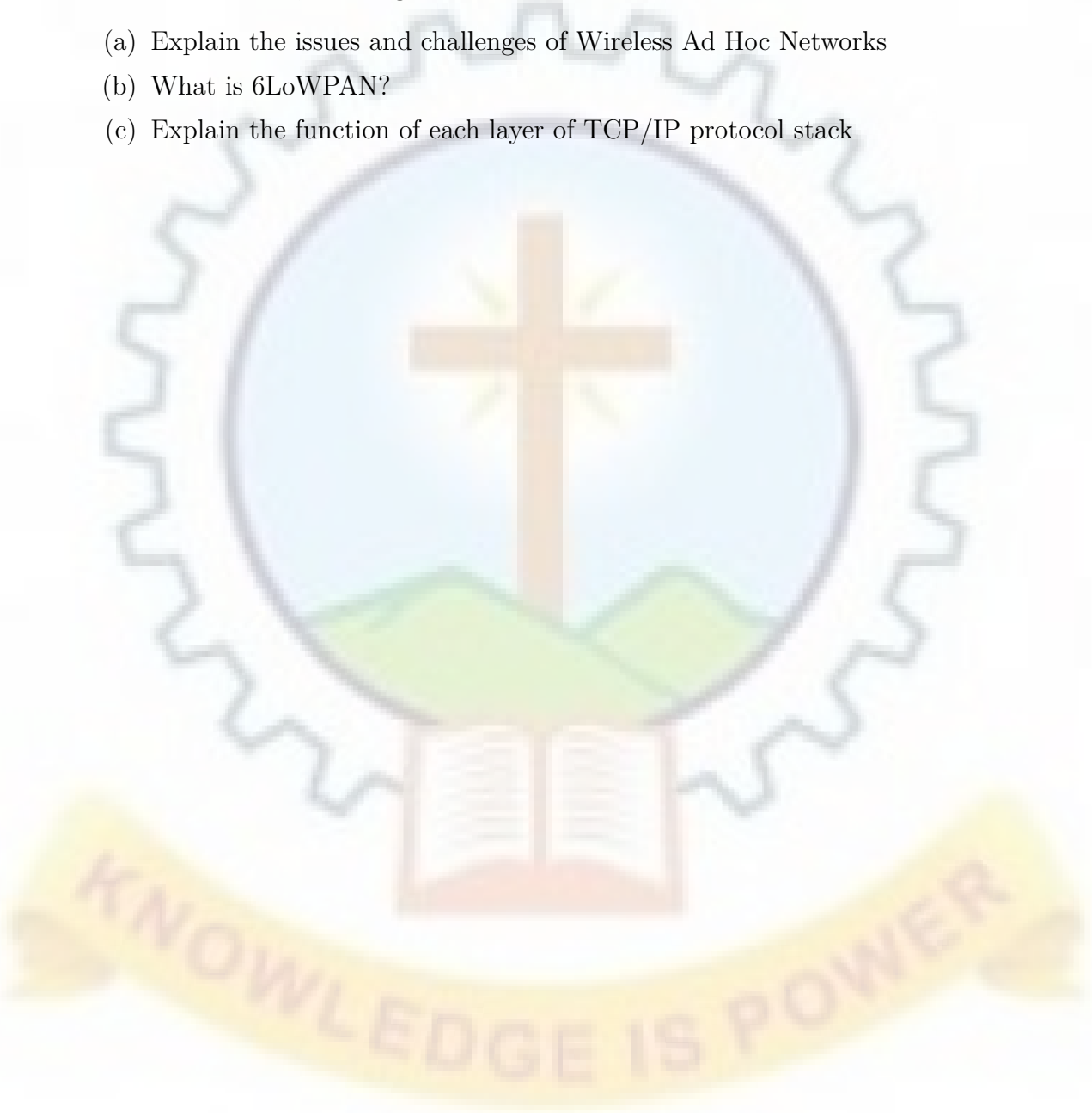
1. Outline the requirement for Satellite communication systems
  - (a) Explain the block diagram for satellite uplink



- (b) What are geostationary satellites?
- (c) Explain various satellite orbits

**Course Outcome 5 (CO 5):**

1. Discuss the issues, challenges and architecture for various wireless ad hoc networks
  - (a) Explain the issues and challenges of Wireless Ad Hoc Networks
  - (b) What is 6LoWPAN?
  - (c) Explain the function of each layer of TCP/IP protocol stack



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 2**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, NOVEMBER 2026**

**Course Code: B24ECM52**

**Course Name: COMMUNICATION SYSTEMS**

Max. Marks: 100

Duration: 3 hours

***PART A***

***Answer all questions. Each question carries 3 marks***

1. Compare the advantages and disadvantages of fiber-optic cables and metallic cables
2. Define Numerical Aperture
3. Write the RADAR range equation
4. Explain the principle of A-scope display
5. Why a honeycomb pattern was is selected for cell area?
6. Distinguish between soft handoff and hard handoff
7. Define Apogee and Perigee
8. Define look angles, angle of elevation and azimuth
9. List the challenges of wireless ad hoc networks
10. Explain 3-way handshaking

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain different losses in Optical Fiber cable (7)  
b) Explain the operation of LED? (7)
12. a) Explain the block diagram for Optical Fiber Communication? (7)  
b) Explain the function of photodiode? (7)

**Module II**

13. a) Explain the block diagram for pulsed RADAR? (7)  
b) Explain the principle of PPI display? (7)
14. a) Derive and explain the qualitative RADAR range equation. Highlight the factors affecting maximum detection range. (7)  
b) Describe the working and significance of Instrument Landing System (ILS) and Ground Controlled Approach (GCA) system? (7)

**Module III**

15. Explain the architecture for GSM. (14)
16. Explain block diagram for CDMA system. (14)

**Module IV**

17. Explain Kepler's law of planetary motion. (14)
18. Explain the block diagram for satellite transponder. (14)

**Module V**

19. Explain the role of each layer in TCP/IP protocol stack (14)
20. Explain various data dissemination protocols used in wireless sensor networks (14)

| B24ECM53 | INTRODUCTION<br>TO DIGITAL<br>IMAGE<br>PROCESSING<br>(Minor) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|----------|--------------------------------------------------------------|---|---|---|---|--------|-------------------------|
|          |                                                              | 3 | 1 | 0 | 5 |        |                         |

### Preamble

This course introduces the fundamental concepts, techniques, and applications of Digital Image Processing (DIP). It covers the theory and practical methods used for digital image acquisition, enhancement, transformation, segmentation, and restoration. Students learn how digital images are represented and processed using computational algorithms for various engineering and research applications. The course also provides a foundation for advanced topics such as computer vision, medical imaging, and machine learning-based image analysis.

### Prerequisites

B24EC2T05 : SIGNALS AND SYSTEM

### Course Outcomes

After the completion of the course, the student will be able to:

|      |                                                                                                                              |
|------|------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Explain the fundamentals of digital image representation, acquisition, and sampling concepts. [Remember, Understand]         |
| CO 2 | Apply spatial and frequency domain techniques for image enhancement and filtering. [Understand, Apply]                       |
| CO 3 | Understand and implement various image transforms such as DFT, Hadamard, Haar, and Walsh transforms. [Understand, Apply]     |
| CO 4 | Develop algorithms for image segmentation and edge detection using thresholding, gradient, and region-based methods. [Apply] |
| CO 5 | Apply image restoration and geometric transformation techniques to improve degraded images. [Apply]                          |

### Mapping of Course Outcomes With Program Outcomes

### Assessment Pattern

### Mark Distribution

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    | 1    | 1    | 2    | 1    |      |      | 1    |       | 1     |
| CO 2 | 3    | 3    | 2    | 1    | 2    | 1    |      | 1    | 1    |       | 1     |
| CO 3 | 3    | 3    | 2    | 2    | 3    | 1    |      | 1    | 1    |       | 2     |
| CO 4 | 2    | 3    | 2    | 2    | 2    | 2    |      | 1    | 1    |       | 2     |
| CO 5 | 2    | 3    | 2    | 2    | 3    | 1    |      | 1    | 1    |       | 3     |

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

## SYLLABUS

### MODULE 1

**Introduction to Digital Image Processing:** Examples of Fields that Use Digital Image Processing, Fundamentals Steps in Image Processing, Elements of Digital Image Processing Systems, Brightness, contrast, hue, saturation, mach band effect Image 2D Sampling and Quantization, Some basic relationships like Neighbours, Connectivity, Distance Measures between pixels. Colour image fundamentals-RGB, CMY, HIS models,

### MODULE 2

**Image Enhancement in the Spatial Domain:** Basic Gray Level Transformations, Histogram Processing, Enhancement Using Arithmetic and Logic operations, Basics of Spatial Filters, Smoothing Spatial Filters: Low pass filters, Order Statistics filters; Sharpening Spatial Filters: Laplacian filter

### MODULE 3

**Image Enhancement in the Frequency Domain:** 2D Image transforms: DFT, its properties, Walsh transform, Hadamard transform, Haar transform Frequency Domain Filtering: Ideal and Butterworth Low pass and High pass filters, Homomorphic Filtering.

### MODULE 4

**Image segmentation: Classification of Image segmentation techniques:** Point, Line and Edge Detection, Gradient and Laplacian based edge detection, Region approach, Segmentation based on thresholding, Canny edge detection, Hough transform

### MODULE 5

**Image Restoration:** Degradation model, Unconstraint restoration- Lagrange multiplier and constraint restoration Inverse filtering- removal of blur caused by uniform linear motion, Weiner filtering, Geometric transformations-spatial transformations.

### Text Books



1. Digital Image Processing, Gonzalez Rafael C, Pearson Education, 2009
2. Digital image processing, S Jayaraman, S Esakkirajan, T Veerakumar, Tata Mc Graw Hill, 2015
3. Fundamentals of Digital Image Processing ,Anil K. Jain Prentice-Hall of India
4. Digital Image Processing Using MATLAB Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins
5. Computer Vision: Algorithms and Applications, Richard Szeliski Springer
6. Digital image processing: Kenneth R Castleman ,Pearson Education, 2/e, 2003



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                         | No of Lecture/Tutorial Hours |
|-----|-----------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                               | <b>7</b>                     |
| 1.1 | Examples of Fields that Use Digital Image Processing, Fundamentals Steps in Image Processing. | 1                            |
| 1.2 | Elements of Digital Image Processing Systems, Brightness, contrast, hue, saturation.          | 1                            |
| 1.3 | mach band effect Image 2D Sampling and Quantization.                                          | 2                            |
| 1.4 | Some basic relationships like Neighbours, Connectivity, Distance Measures between pixels.     | 1                            |
| 1.5 | Colour image fundamentals-RGB, CMY, HIS models.                                               | 2                            |
|     | <b>Module 2</b>                                                                               | <b>10</b>                    |
| 2.1 | Some basic Gray Level Transformations.                                                        | 2                            |
| 2.2 | Histogram Processing.                                                                         | 2                            |
| 2.3 | Enhancement Using Arithmetic and Logic operations.                                            | 1                            |
| 2.4 | Basics of Spatial Filters.                                                                    | 1                            |
| 2.5 | Smoothing Spatial Filters: Low pass filters, Order Statistics filters.                        | 2                            |
| 2.6 | Sharpening Spatial Filters: Laplacian filter.                                                 | 2                            |
|     | <b>Module 3</b>                                                                               | <b>9</b>                     |
| 3.1 | 2D Image transforms: DFT, its properties.                                                     | 2                            |
| 3.2 | DWalsh transform, Hadamard transform, Haar transform.                                         | 4                            |
| 3.3 | Frequency Domain Filtering: Ideal and Butterworth Low pass and High pass filters.             | 2                            |
| 3.4 | Homomorphic Filtering.                                                                        | 1                            |
|     | <b>Module 4</b>                                                                               | <b>9</b>                     |
| 4.1 | Classification of Image segmentation techniques.                                              | 1                            |
| 4.2 | Point, Line and Edge Detection                                                                | 2                            |
| 4.3 | Gradient and Laplacian based edge detection                                                   | 2                            |
| 4.4 | Region approach, Segmentation based on thresholding.                                          | 2                            |
| 4.5 | Canny edge detection, Hough transform.                                                        | 2                            |
|     | <b>Module 5</b>                                                                               | <b>8</b>                     |
| 5.1 | Degradation model.                                                                            | 1                            |
| 5.2 | Unconstrained restoration- Lagrange multiplier and constraint restoration                     | 1                            |
| 5.3 | restoration Inverse filtering- removal of blur caused by uniform linear motion.               | 2                            |
| 5.4 | Weiner filtering. Geometric transformations-spatial transformations                           | 4                            |
|     | <b>Total Hours</b>                                                                            | <b>43 Hours</b>              |

## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1):**

1. Explain pixel connectivity and neighborhood relationships with diagrams.
2. Describe RGB and HSI color models and state the conversion formula.

### **Course Outcome 2 (CO 2):**

1. Distinguish between smoothing and sharpening spatial filters.
2. Explain the Laplacian filter and its application in image sharpening.

### **Course Outcome 3 (CO 3):**

1. Write the 2-D DFT equation and list its properties.
2. What is homomorphic filtering? Explain with block diagram.

### **Course Outcome 4 (CO 4):**

1. Describe Sobel and Prewitt operators with masks.
2. What is Hough transform? Explain its use in line detection.

### **Course Outcome 5 (CO 5):**

1. Differentiate between constrained and unconstrained restoration.
2. Describe motion blur and its removal method using inverse filtering.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24ECM53**

**Course Name: INTRODUCTION TO DIGITAL IMAGE PROCESSING**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define sampling and quantization in digital images.
2. Explain the concepts of 4-neighbours, 8-neighbours and connectivity in images.
3. Explain histogram equalization.
4. What are Laplacian and Sobel operators? State their uses.
5. Compare Ideal, Butterworth and Gaussian filters.
6. List the advantages of Walsh transform over Fourier Transform..
7. What is Canny edge detector? List its major steps.
8. Illustrate the use of derivative operation in edge detection.
9. What is inverse filtering?
10. List any three causes that can result in image degradation.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Elaborate on the importance of 2D sampling in digital image processing and discuss the process of quantization (8)

b) Define the terms brightness, contrast and hue with respect to digital images. (6)

12. a) Discuss the conceptual relationship between the RGB and HIS colour models with neat sketches. (10)

b) Differentiate between spatial resolution and intensity resolution. (4)

### Module II

13. a) Explain the concept of image averaging in spatial domain methods. Discuss its role in reducing noise and enhancing image quality. Provide examples and discuss the limitations of image averaging. (7)

b) Compute the 2-D DFT of a  $2 \times 2$  matrix given

$$x[m, n] = \begin{bmatrix} 201 & 124 \\ 345 & 267 \end{bmatrix}$$

(7)

14. a) Perform histogram equalization of the following image

$$\begin{bmatrix} 3 & 7 & 6 & 2 & 0 \\ 2 & 4 & 6 & 1 & 1 \\ 4 & 7 & 2 & 5 & 4 \\ 3 & 0 & 6 & 2 & 1 \\ 5 & 7 & 5 & 1 & 2 \end{bmatrix}$$

(7)

b) Explain the point operations used in image enhancement. (7)

### Module III

15. a) Illustrate the algorithmic steps to generate Haar basis. (7)

b) For the image segment

$$I = \begin{bmatrix} 2 & 2 \\ 1 & 3 \end{bmatrix}$$

compute the transform coefficients using DFT

(7)

16. a) State and prove any two properties of 2D DFT. (7)

b) Explain the steps involved in homomorphic filtering. (7)

### Module IV

17. a) Explain region splitting and merging in image segmentation with neat schematics. (8)  
b) Discuss Canny edge detection in detail. (6)
18. a) Explain the method of global thresholding for image segmentation (7)  
b) Explain the use of Hough transform for line detection. (7)

**Module V**

19. a) Explain the concept of a degradation model in image restoration. Discuss how it represents the relationship between the original and degraded images. (7)  
b) Explain image restoration using inverse filtering techniques. Give its limitations.
20. a) Discuss the Wiener filtering technique in image restoration. Explain how it considers both the characteristics of the image and the noise to enhance the. (7)  
b) Explain the various geometric transformations. (7)



| <b>B24ECH51</b> | <b>SYSTEM<br/>VERILOG FOR<br/>DESIGN AND<br/>VERIFICATION<br/>(Honours)</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF<br/>INTRODUCTION</b> |
|-----------------|-----------------------------------------------------------------------------|----------|----------|----------|----------|---------------|---------------------------------|
|                 |                                                                             | 3        | 1        | 0        | 5        |               |                                 |

**Preamble**

This course provides a comprehensive foundation in verification principles and practical methodologies using System Verilog. It covers key topics such as test bench architecture, data types, object-oriented programming concepts, constrained randomization, interprocess communication, and functional coverage.

Students will learn to develop reusable and layered verification environments, apply constraint-driven testing techniques, utilize assertions, and analyze coverage metrics to measure verification quality. Emphasizing both conceptual understanding and practical skills, the course prepares learners for professional roles in digital design verification and validation.

**Prerequisites**

B24EC1T03 : LOGIC CIRCUIT DESIGN

B24ECH41 : NANO ELECTRONICS

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                                     |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the System Verilog verification process and apply appropriate data types and test bench components to design an efficient verification environment. [Understand, Apply]  |
| <b>CO 2</b> | Apply procedural statements, routines, and interface constructs in System Verilog to effectively connect the test bench with the design under verification. [Understand, Apply]     |
| <b>CO 3</b> | Apply object-oriented programming concepts in System Verilog to design modular, reusable, and scalable verification environments. [Understand, Apply]                               |
| <b>CO 4</b> | Analyse constrained randomization techniques in System Verilog to generate effective test stimuli and enhance functional verification coverage. [Remember, Analyse]                 |
| <b>CO 5</b> | Utilize interprocess communication mechanisms and functional coverage techniques in SystemVerilog to monitor, analyse, and improve verification completeness. [Understand, Analyse] |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| CO 2 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| CO 3 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| CO 4 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| CO 5 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 30                    | 30              | 30                                 |
| Analyse          | 20                    | 20              | 20                                 |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.

Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.



## SYLLABUS

### MODULE 1

**Verification guidelines and Data types, Verification guidelines:** Verification Process, Basic Test bench functionality, directed testing, Methodology basics, Constrained-Random stimulus, Functional coverage, Test bench components, Layered test bench, Building layered test bench, Simulation environment phases, Maximum code reuse, Test bench performance. Data types: Built-in data types, Fixed-size arrays, Dynamic arrays, Queues, Associative Arrays, Linked lists, Array methods, choosing a storage type, creating new types with typedef, Creating user-defined structures, Type conversion, Enumerated types, Constants, strings, expression width.

### MODULE 2

**Routines and Connecting the test bench & design:** Procedural statements and routines: Procedural statements, tasks, functions and void Functions, Routine arguments, returning from routine, local data storage, Time values. Connecting the test bench and design: Separating the test bench and design, Interface constructs, Stimulus timing, Interface driving and sampling, connecting it all together, Top-level scope, Program – Module interactions, System Verilog assertions.

### MODULE 3

**Basic OOP:** Introduction, first class, define a class, OOP(Object Oriented Programming) terminology, Creating new objects, Object de-allocation, Using objects, Static variables vs. Global variables, Class methods, Defining methods outside of the class, Scoping rules, Using one class inside another, Understanding dynamic objects, Copying objects, Public vs. private, Straying off course, building a test bench.

### MODULE 4

**Randomization:** Introduction, randomization, Randomization in System Verilog, Constraint details, solution probabilities, Controlling multiple constraint blocks, Valid constraints, In-line constraints, The pre randomize and post randomize functions, Constraints tips and techniques, common randomization problems.

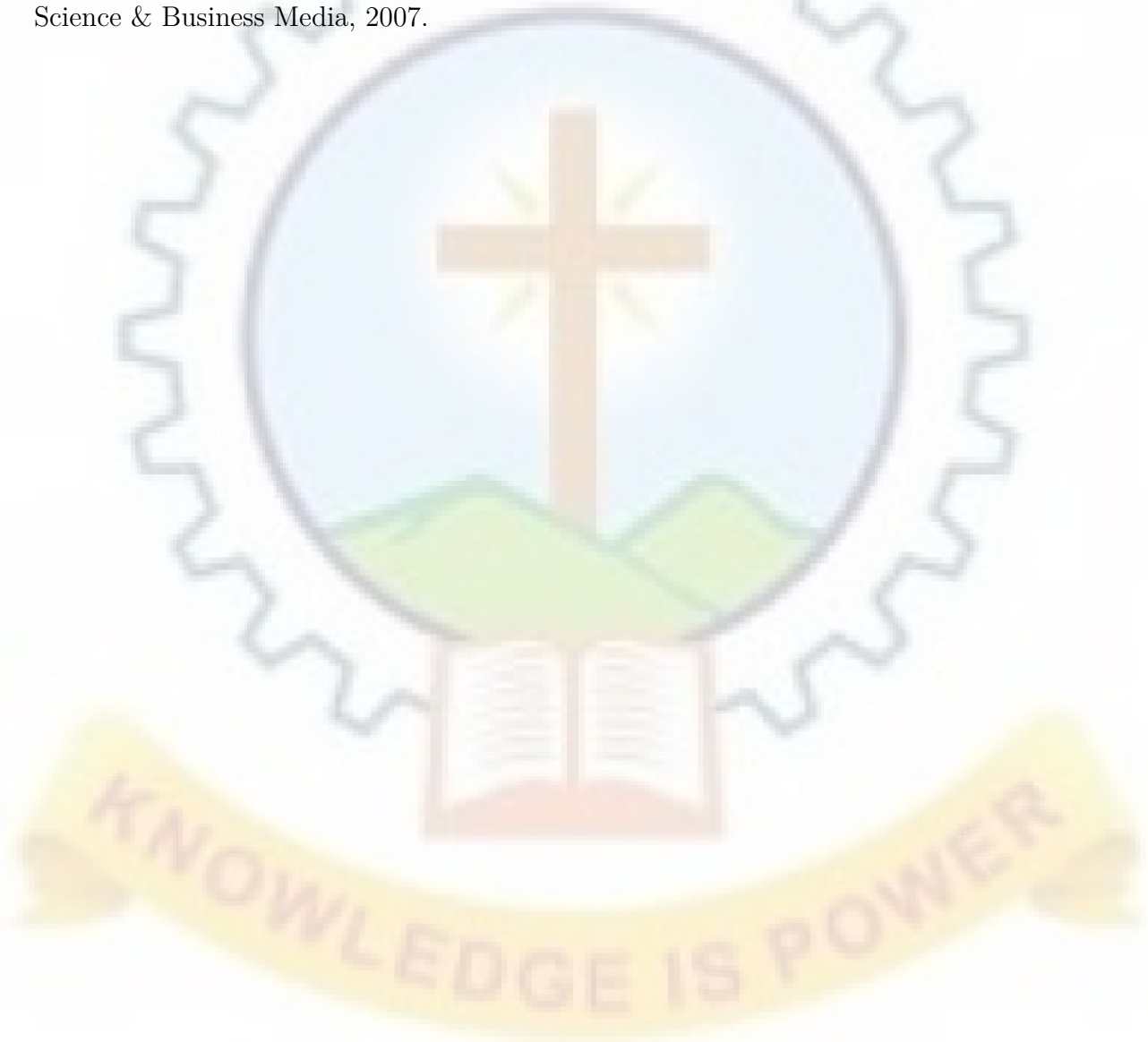
### MODULE 5

**Interprocess communication and Functional Coverage:** Interprocess Communica-

tion, Events, Semaphores, Mailboxes, Coverage Types, Functional Coverage Strategies, Simple Functional Coverage Example, Anatomy of a Cover Group, Triggering a Cover Group, Data Sampling, Cross Coverage, Generic Cover Groups, Coverage Options, Analyzing Coverage Data, Measuring Coverage Statistics During Simulation.

**Text Books**

1. Chris Spears, System Verilog for Verification, 2nd Edition, Springer, 2008.
2. Vijayaraghavan , Srikanth, and Meyyappan Ramanathan. A practical guide for System Verilog assertions, Springer Science & Business Media, 2006.
3. Bergeron, Janick . Writing test benches using System Verilog, 1st Edition, Springer Science & Business Media, 2007.



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                                                                                          | No of Lecture/Tutorial Hours |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                                                                                                | <b>9</b>                     |
| 1.1 | Verification guidelines and Data types: Verification guidelines: Verification Process, Basic Test bench functionality, directed testing, Methodology basics.                                                                   | 2                            |
| 1.2 | Constrained-Random stimulus, Functional coverage, Test bench components, Layered test bench, Building layered test bench.                                                                                                      | 1                            |
| 1.3 | Simulation environment phases, Maximum code reuse, Test bench performance.                                                                                                                                                     | 1                            |
| 1.4 | Data types: Built-in data types, Fixed-size arrays, Dynamic arrays, Queues, Associative Arrays, Linked lists.                                                                                                                  | 2                            |
| 1.5 | Array methods, choosing a storage type, creating new types with typedef, Creating user-defined structures.                                                                                                                     | 2                            |
| 1.6 | Type conversion, Enumerated types, Constants, strings, expression width.                                                                                                                                                       | 1                            |
|     | <b>Module 2</b>                                                                                                                                                                                                                | <b>9</b>                     |
| 2.1 | Routines and Connecting the test bench & design: Procedural statements and routines: Procedural statements, tasks, functions and void Functions, Routine arguments, returning from routine, local data storage, Time values. . | 3                            |
| 2.2 | Always block for Connecting the test bench and design: Separating the test bench and design, Interface constructs.                                                                                                             | 2                            |
| 2.3 | Stimulus timing, Interface driving and sampling, connecting it all together.                                                                                                                                                   | 2                            |
| 2.4 | Top-level scope, Program – Module interactions, System Verilog assertions.                                                                                                                                                     | 2                            |
|     | <b>Module 3</b>                                                                                                                                                                                                                | <b>9</b>                     |
| 3.1 | Basic OOP:Introduction, first class, define a class, OOP(Object Oriented Programming) terminology, Creating new objects, Object de-allocation, Using objects.                                                                  | 2                            |
| 3.2 | Static variables vs. Global variables, Class methods, Defining methods outside of the class, Scoping rules, Using one class inside another.                                                                                    | 3                            |
| 3.3 | Understanding dynamic objects, Copying objects, Public vs. private.                                                                                                                                                            | 2                            |
| 3.4 | Straying off course, building a test bench.                                                                                                                                                                                    | 2                            |
|     | <b>Module 4</b>                                                                                                                                                                                                                | <b>9</b>                     |
| 4.1 | Randomization:Introduction, randomization, Randomization in System Verilog.                                                                                                                                                    | 2                            |



|     |                                                                                                                                |                 |
|-----|--------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 4.2 | Constraint details, solution probabilities, Controlling multiple constraint blocks, Valid constraints, In-line constraints.    | 3               |
| 4.3 | The pre randomize and post randomize functions.                                                                                | 2               |
| 4.4 | Constraints tips and techniques, common randomization problems.                                                                | 2               |
|     | <b>Module 5</b>                                                                                                                | <b>9</b>        |
| 5.1 | Interprocess communication and Functional Coverage: Interprocess Communication, Events, Semaphores, Mailboxes, Coverage Types. | 2               |
| 5.2 | Functional Coverage Strategies, Simple Functional Coverage Example, Anatomy of a Cover Group, Triggering a Cover Group.        | 2               |
| 5.3 | Data Sampling, Cross Coverage, Generic Cover Groups, Coverage Options.                                                         | 3               |
| 5.4 | Analyzing Coverage Data, Measuring Coverage Statistics During Simulation.                                                      | 2               |
|     | <b>Total Hours</b>                                                                                                             | <b>45 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Write a testbench fragment that demonstrates the use of semantically layered components (driver, monitor, scoreboard).
2. Apply constrained-random stimulus to generate 100 random transactions for an 8-bit adder module.

#### Course Outcome 2 (CO 2):

1. Apply routine arguments by writing a task that takes input, output, and inout arguments to swap two variables.
2. Demonstrate returning values from functions and use them in conditional statements to control signal assignments.

**Course Outcome 3 (CO 3):**

1. Develop a code that demonstrates the use of multiple objects of the same class interacting with different sets of data.
2. Write System Verilog code to define a method outside the class definition and invoke it using a class handle.

**Course Outcome 4 (CO 4):**

1. Write a program that shows how randc (cyclic randomization) can be used to generate non-repeating random values.
2. Implement pre randomize() and post randomize() functions in a class to initialize and log random values before and after randomization.

**Course Outcome 5 (CO 5):**

1. Implement non-blocking and blocking mailbox operations in a testbench and explain their behavioral difference.
2. Develop code demonstrating how a cover group can be triggered automatically on a clock edge or event.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 3**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, NOVEMBER 2026**

**Course Code: B24ECH51**

**Course Name: SYSTEM VERILOG FOR DESIGN AND VERIFICATION**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. What are the main components of a testbench? Illustrate with a simple block diagram.
2. Write a code snippet demonstrating the use of typedef to simplify data type declarations.
3. What is the purpose of initial and always procedural blocks in testbenches?
4. Explain the difference between immediate and concurrent assertions with examples.
5. Define a class in System Verilog and write the syntax for class declaration.
6. What is the purpose of using class-based randomization in verification?
7. What is the difference between directed testing and constrained-random testing?
8. Write a short note on constraint debugging techniques.
9. Explain with an example how semaphores prevent race conditions.
10. Define functional coverage and explain its importance in verification.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain the verification process in System Verilog. Illustrate the role of directed testing, constrained-random stimulus, and functional coverage with a suitable example. (7)  
b) Draw a layered testbench architecture and explain the function of each layer (generator, driver, monitor, scoreboard, environment). (7)
12. a) Explain the use of linked lists in testbench design. Write a code example to insert, delete, and traverse elements in a linked list. (7)  
b) Explain enumerated types and constants in SystemVerilog. Write an example showing their usage in ALU operations. (7)

### **Module II**

13. a) Discuss the difference between function and void function in System Verilog. Provide a small code example for each. (7)  
b) Write a System Verilog program demonstrating nested tasks and functions. Also explain the flow of execution. (7)
14. a) Explain program-module interactions and the execution order of program blocks vs design modules. (7)  
b) Explain the concept of top-level scope in System Verilog and how it affects variable access in the testbench. (7)

### **Module III**

15. a) Explain the steps to define a class, create objects, and de-allocate objects in System Verilog. Write a small code example showing creation and deletion of a packet object. (7)  
b) Explain the difference between shallow copy and deep copy of objects. Write an example to illustrate. (7)
16. a) Write an example showing passing an object handle between classes in a testbench and explain the benefit. (7)  
b) Explain straying off course in OOP-based verification and suggest best practices to avoid it. (7)

### **Module IV**

17. Explain interprocess communication in System Verilog and its importance in verification. Compare events, semaphores, and mailboxes in terms of usage, advantages, and limitations. Include a small example for each. (14)
18. Explain the concept of randomization in System Verilog and its importance in verification. Compare directed testing and constrained-random testing. Illustrate with a small example class containing addr, data, and cmd fields, and show how constrained randomization is applied. (14)

**Module V**

19. Design a generic covergroup in System Verilog that can be reused for multiple types of transactions. Explain its benefits for scalable verification environments. (14)
20. Discuss the use of coverage options (goal, weight, at least) and how they influence coverage reporting. Include a code snippet demonstrating their use. (14)



| <b>B24ECH52</b> | <b>DETECTION<br/>AND<br/>ESTIMATION<br/>THEORY<br/>(Honours)</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF<br/>INTRODUCTION</b> |
|-----------------|------------------------------------------------------------------|----------|----------|----------|----------|---------------|---------------------------------|
|                 |                                                                  | 3        | 1        | 0        | 5        |               |                                 |

**Preamble**

This course introduces the fundamentals and applications of Detection and Estimation Theory, essential for statistical signal processing and decision-making under uncertainty. It covers hypothesis testing, classical and Bayesian detection methods, estimation techniques including minimum variance, maximum likelihood, least squares, and Bayesian estimation, with emphasis on practical applications. Students will develop the analytical and computational skills to model, analyze, and solve real-world detection and estimation problems.

**Prerequisites**

B24EC2T05 : SIGNALS AND SYSTEMS

B24ECH42 : STOCHASTIC PROCESS FOR COMMUNICATION

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                                                        |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the fundamentals of detection and estimation theory and the mathematical formulation of detection and estimation problems.[Understand,Apply]                                                |
| <b>CO 2</b> | Apply likelihood ratio tests and evaluate performance using receiver operating characteristics. [Apply, Analyse]                                                                                       |
| <b>CO 3</b> | Apply detection techniques for deterministic and random signals using matched filters and estimator-correlators. [Remember, Apply]                                                                     |
| <b>CO 4</b> | Understand the minimum variance unbiased estimation and the Cramer-Rao lower bound (CRLB) and apply best linear unbiased estimation (BLUE) in linear models to practical examples. [Understand, Apply] |
| <b>CO 5</b> | Apply maximum likelihood, least squares, and Bayesian estimation techniques to real problems. [Understand, Apply]                                                                                      |



### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| CO 2 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| CO 3 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| CO 4 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| CO 5 | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 30                    | 30              | 30                                 |
| Analyse          | 20                    | 20              | 20                                 |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.

Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.



## SYLLABUS

### MODULE 1

**Introduction to Detection and Estimation Theory:** Fundamentals of detection theory, the mathematical detection problem. Fundamentals of estimation theory, the mathematical estimation problem. Review of Gaussian distribution. Application examples.

### MODULE 2

**Statistical Detection Theory I:** Hypothesis testing, classical approach, Neyman-Pearson theorem, likelihood ratio test, receiver operating characteristics, Bayesian approach, minimum probability of error, Bayes risk, multiple hypothesis testing.

### MODULE 3

**Statistical Detection Theory II:** Detection of deterministic signals, matched filters, detection of random signals, estimator- correlator, linear model, application examples.

### MODULE 4

**Statistical Estimation Theory I:** Minimum variance unbiased estimation, basics of Cramer-Rao Lower Bound, linear models, best linear unbiased estimation, application examples.

### MODULE 5

**Module 5 : Statistical Estimation Theory II:** Maximum likelihood estimation, least squares, Bayesian philosophy, minimum mean square error estimation, application examples.

### Text Books

1. S.M. Kay, "Fundamentals of Statistical Signal Processing" Vol I: Estimation Theory, Pearson, 3/e, 2010.
2. S.M. Kay, "Fundamentals of Statistical Signal Processing" Vol II: Detection Theory, Pearson, 3/e, 2010.
3. H. L. Van Trees, "Detection, Estimation, and Modulation Theory", Vol. I, John Wiley & Sons, 1968.
4. Monson H. Hayes, "Statistical Digital Signal Processing and Modelling" by, John Wiley & Sons, 2002.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                                        | No of Lecture/Tutorial Hours |
|-----|------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                              | <b>9</b>                     |
| 1.1 | Fundamentals of detection theory, review of probability and random variable. | 2                            |
| 1.2 | The mathematical detection problem.                                          | 2                            |
| 1.3 | Fundamentals of estimation theory.                                           | 1                            |
| 1.4 | The mathematical estimation problem.                                         | 2                            |
| 1.5 | Review of Gaussian distribution. Application examples.                       | 2                            |
|     | <b>Module 2</b>                                                              | <b>9</b>                     |
| 2.1 | Hypothesis testing .                                                         | 2                            |
| 2.2 | Classical approach, Neyman-Pearson theorem.                                  | 2                            |
| 2.3 | Likelihood ratio test, Receiver operating characteristics.                   | 2                            |
| 2.4 | Bayesian approach, minimum probability of error, Bayes risk.                 | 2                            |
| 2.5 | Multiple hypothesis testing.                                                 | 1                            |
|     | <b>Module 3</b>                                                              | <b>9</b>                     |
| 3.1 | Detection of deterministic signals.                                          | 1                            |
| 3.2 | Matched filters.                                                             | 2                            |
| 3.3 | Detection of random signals.                                                 | 2                            |
| 3.4 | Estimator-correlator.                                                        | 2                            |
| 3.5 | Linear model, application examples.                                          | 2                            |
|     | <b>Module 4</b>                                                              | <b>9</b>                     |
| 4.1 | Minimum variance unbiased estimation.                                        | 2                            |
| 4.2 | Basics of Cramer-Rao Lower Bound.                                            | 2                            |
| 4.3 | Linear models.                                                               | 2                            |
| 4.4 | Best linear unbiased estimation.                                             | 2                            |
| 4.5 | Application examples.                                                        | 1                            |
|     | <b>Module 5</b>                                                              | <b>9</b>                     |
| 5.1 | Maximum likelihood estimation.                                               | 2                            |
| 5.2 | Least squares solution.                                                      | 2                            |
| 5.3 | Bayesian philosophy.                                                         | 2                            |
| 5.4 | Minimum mean square error estimation.                                        | 2                            |
| 5.5 | Application examples.                                                        | 1                            |
|     | <b>Total Hours</b>                                                           | <b>45 Hours</b>              |

## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1):**

1. Derive the probability density function of a Gaussian random variable.
2. Consider a sensor measuring temperature with Gaussian noise. Formulate a simple detection problem for identifying if the temperature exceeds a threshold.

### **Course Outcome 2 (CO 2):**

1. Explain the classical approach to hypothesis testing and the role of the Neyman-Pearson theorem.
2. Derive the likelihood ratio test for a binary hypothesis problem.

### **Course Outcome 3 (CO 3):**

1. Derive the matched filter for a known deterministic signal in additive white Gaussian noise (AWGN).
2. Explain the operation of an estimator-correlator for detecting random signals.

### **Course Outcome 4 (CO 4):**

1. Derive the Cramer-Rao Lower Bound for an unbiased estimator of a parameter.
2. Explain how the linear model assumptions affect the applicability of BLUE in practical systems.

### **Course Outcome 5 (CO 5):**

1. Explain the Bayesian approach to estimation and derive the Bayesian estimator for a given prior and likelihood.
2. Compute the minimum mean square error (MMSE) estimator for a given set of observations and prior information.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 3**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, NOVEMBER 2026**

**Course Code: B24ECH52**

**Course Name: DETECTION AND ESTIMATION THEORY**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Enumerate different applications which are using estimation and detection techniques.
2. Differentiate estimation and detection techniques.
3. Differentiate classical approach and bayesian approach in detection theory.
4. Give the mathematical formulation of detection methods.
5. Draw receiver operating characteristics with all details.
6. Give the significance of Bayes risk.
7. Give the significance of linear models in estimation theory.
8. What is the importance of Cramer-Rao Lower Bound in estimation.
9. What is Minimum Variance Unbiased Estimation?
10. Differentiate MAP and ML methods in estimation.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**



11. a) Formulate the mathematical detection problem for a simple scenario where a sensor observes a signal corrupted by Gaussian noise. Explain the decision criteria. (7)  
b) Provide an example of a real-world application where both detection and estimation are used. Explain how Gaussian modeling is applied in that scenario. (7)
12. a) Define detection theory and estimation theory. Explain their differences and discuss their importance in statistical signal processing. (7)  
b) Explain the mathematical estimation problem. Given a set of noisy measurements, describe how an estimator can be designed to estimate the underlying parameter. (7)

### **Module II**

13. a) Define hypothesis testing and explain the difference between null and alternative hypotheses. Illustrate the concept with a simple detection example. (7)  
b) Explain the Neyman-Pearson theorem. Derive the likelihood ratio test (LRT) for a binary hypothesis problem and state its significance (7)
14. a) Derive the likelihood ratio test (LRT) for detecting a deterministic signal in Gaussian noise and discuss how the decision threshold affects detection performance. (7)  
b) Compare the classical and Bayesian approaches to hypothesis testing. Highlight their advantages, limitations, and typical applications. (7)

### **Module III**

15. a) Derive the matched filter detector for a known deterministic signal in noise. Explain how the matched filter maximizes the signal-to-noise ratio (SNR). (7)  
b) What is an estimator-correlator? Explain its operation for the detection of random signals and show how it relates to the likelihood ratio test. (7)
16. a) Discuss a real-world application example where matched filter detection is employed. Explain how detection performance is measured. (7)  
b) Describe the linear model used in statistical detection. Derive the general form of the detection statistic for the linear model and explain its significance.. (7)

### **Module IV**

17. Discuss the relationship between unbiasedness, efficiency, and consistency in estimation theory. Provide examples of estimators that satisfy or violate these properties and explain their implications in practical estimation problems. (14)
18. Define and explain the concept of a Minimum Variance Unbiased Estimator (MVUE). Derive the conditions under which an estimator can be considered unbiased and discuss the significance of variance minimization in estimator design. Provide a suitable example. (14)

**Module V**

19. Prove that the optimal estimator which minimizes the Bayesian Mean Square Error is the mean of the posterior PDF. (14)
20. For a random variable  $X$  with Gaussian noise, derive and compare the MMSE and MLE estimators. Discuss under what conditions both estimators yield the same result. (14)



| B24ECH53 | COMPUTATIONAL<br>TOOLS FOR<br>SIGNAL<br>PROCESSING<br>(Honours) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|----------|-----------------------------------------------------------------|---|---|---|---|--------|-------------------------|
|          |                                                                 | 3 | 1 | 0 | 5 |        |                         |

### Preamble

This course aims to use the computational tools in signal processing to solve industry problems.

### Prerequisites

B24EC1L02 Scientific Computing Lab  
B24EC2T05 Signals and Systems  
B24EC3T01 Digital Signal Processing

### Course Outcomes

After the completion of the course, the student will be able to:

|      |                                                                              |
|------|------------------------------------------------------------------------------|
| CO 1 | Compute posterior probability using pymc3 for practical applications [Apply] |
| CO 2 | Compute linear and logistic regression with pymc3. [Apply]                   |
| CO 3 | Perform Bayesian analysis for practical applications. [Understand, Apply]    |
| CO 4 | Implement Kalman filters. [Understand, Apply]                                |
| CO 5 | Implement particle filters for practical applications. [Understand, Apply]   |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 3    |      |      | 3    |      |      |      |      |       | 2     |
| CO 2 | 3    | 3    | 2    | 3    | 3    |      |      |      |      |       | 2     |
| CO 3 | 3    | 3    | 2    | 3    | 3    | 2    |      |      |      |       | 2     |
| CO 4 | 3    | 3    | 2    | 3    | 3    | 2    |      |      |      |       | 2     |
| CO 5 | 3    | 3    | 2    | 3    | 3    | 2    |      |      |      |       | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 10                    | 10                 | 20                                    |
| Understand       | 30                    | 30                 | 60                                    |
| Apply            | 10                    | 10                 | 20                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Probabilistic Programming:** Statistical Modelling using pymc3, Probability concepts, Bayes theorem, Bayesian Statistics and modelling, Modelling Coin flipping as Bayesian, Choosing the likelihood and prior, Posterior computation, Posterior predictive analysis, Posterior plots. Likelihood theory and Estimation.

### MODULE 2

**Modelling Linear and Logistic Regression:** Modelling Linear Regression, Polynomial Regression, Multiple Linear Regression, Logistic Regression, Poisson Regression using pymc3.

### MODULE 3

**Bayesian Modelling:** Bayesian analysis using pymc3, Posterior predictive checks, Model specifications using pymc3, Examples of Bayesian Analytics. Bayes factor, Sequential Monte carlo to compute Bayes factors, Recursive state estimation, Modeling functions using pymc3, Covariance functions and kernels, Bayesian Regression Models.

### MODULE 4

**GH and Kalman Filter:** GH filter, Choosing G and H factors, Simple simulation models using GH filters, Discrete Bayes Filter for predicting the random movement, Recursive estimation and prediction, Effect of noisy environment. Kalman filter- updation using measurements and observations, Kalman Gain calculation and Prediction, Process noise and Measurement noise. Kalman Filter Equations implementation in python.

### MODULE 5

**Particle Filter:** Multivariate Kalman Filter-Modelling and Designing, Effect of Nonlinearity, Nonlinear Filters, Smoothing, Adaptive Filtering. Markov concepts, Monte carlo integration, Basics of Markov chain Monte Carlo, Implementation using filterpy module. Particle Filter algorithm and Implementation.

### Text Books

1. “Bayesian Analysis with python”, Osvaldo Martin, PACKT Open Source Publishing
2. “Machine Learning: A Bayesian and Optimization Perspective”, Sergios Theodoridis,

Academic Press.

3. “Ipython Interactive Computing and Visualization Cookbook”, Cyrille Rossant , PACKT Open Source Publishing

4.“Bayesian Signal Processing: Classical, Modern, and Particle Filtering Methods”, JamesV.Candy, Wiley-IEEE Press





## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                                                       | No of Lecture/Tutorial Hours |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                                                             | <b>10</b>                    |
| 1.1 | Statistical Modelling using pymc3, Probability concepts                                                                                                                                     | 3                            |
| 1.2 | Bayes theorem, Bayesian Statistics and modelling                                                                                                                                            | 2                            |
| 1.3 | Modelling Coin flipping as Bayesian, Choosing the likelihood and prior, Posterior computation                                                                                               | 2                            |
| 1.4 | Posterior predictive analysis, Posterior plots. Likelihood theory and Estimation                                                                                                            | 3                            |
|     | <b>Module 2</b>                                                                                                                                                                             | <b>8</b>                     |
| 2.1 | Modelling Linear Regression                                                                                                                                                                 | 2                            |
| 2.2 | Polynomial Regression, Multiple Linear Regression                                                                                                                                           | 2                            |
| 2.3 | Logistic Regression, Poisson Regression using pymc3                                                                                                                                         | 4                            |
|     | <b>Module 3</b>                                                                                                                                                                             | <b>9</b>                     |
| 3.1 | Bayesian analysis using pymc3, Posterior predictive checks, Model specifications using pymc3, Examples of Bayesian Analytics.                                                               | 3                            |
| 3.2 | Bayes factor, Sequential Monte carlo to compute Bayes factors, Recursive state estimation, Modeling functions using pymc3, Covariance functions and kernels.                                | 4                            |
| 3.3 | Bayesian Regression Models.                                                                                                                                                                 | 2                            |
|     | <b>Module 4</b>                                                                                                                                                                             | <b>8</b>                     |
| 4.1 | GH filter, Choosing G and H factors, Simple simulation models using GH filters                                                                                                              | 2                            |
| 4.2 | Discrete Bayes Filter for predicting the random movement, Recursive estimation and prediction, Effect of noisy environment.                                                                 | 2                            |
| 4.3 | Kalman filter- updation using measurements and observations, Kalman Gain calculation and Prediction, Process noise and Measurement noise. Kalman Filter Equations implementation in python. | 4                            |
|     | <b>Module 5</b>                                                                                                                                                                             | <b>10</b>                    |
| 5.1 | Multivariate Kalman Filter - Modelling and Designing                                                                                                                                        | 2                            |
| 5.2 | Effect of Nonlinearity, Nonlinear Filters, Smoothing, Adaptive Filtering                                                                                                                    | 2                            |
| 5.3 | Markov concepts, Monte carlo integration, Basics of Markov chain Monte Carlo                                                                                                                | 2                            |
| 5.4 | Implementation using filterpy module. Particle Filter algorithm and Implementation.                                                                                                         | 4                            |
|     | <b>Total Hours</b>                                                                                                                                                                          | <b>45 Hours</b>              |

## CO ASSESSMENT QUESTIONS

### Course Outcome 1 (CO 1):

1. Write Python code to compute the posterior distribution of a 10X10 Gaussian random data set.
2. Write Python function to compute the autocorrelation of a 5X5 uniform random data.

### Course Outcome 2 (CO 2):

1. Write a python code to design a regression model by coding setosa =0, versicolor =1, and virginica = 2 in IRIS data set.
2. Write a python code using pymc3 to estimate regression parameters using a simple linear model  $y=ax+b$ , where  $y$  is Normally distributed with mean  $ax+b$  and variance  $\sigma^2$

### Course Outcome 3 (CO 3):

1. Write a python code using pymc3 to compute the bayes factor for the coin toss using a uniform prior  $\text{beta}(1,1)$  . Set  $p(\text{heads})=0.5$
2. Write a python code using pymc3 to implement a Bayesian regression model with intercept 1 and slope 3. Use posterior predictive checks to validate the model.

### Course Outcome 4 (CO 4):

1. Write a python code to predict a random walk using discrete Bayes filter.
2. Write a python code to track the movement of an accelerating aircraft using Kalman filter.

### Course Outcome 5 (CO 5):

1. .Write a python code using pymc3 to create a model that specifies the posterior probability of human sleeping pattern as a function of time using MCMC method.
2. Write a python code to track a robotic movement using Particle Filter.

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2026

**Course Code: B24ECH53**

**Course Name: COMPUTATIONAL TOOLS FOR SIGNAL PROCESSING**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. State Bayes theorem and explain the significance of the terms prior, likelihood and posterior.
2. Write Python code with pymc3 to realize a Bernoulli trial with  $p(\text{head}) = 0.4$ .
3. Compare logistic and linear regression.
4. Explain the concept of Poisson regression and logistic regression.
5. Write the significance of choosing conjugate priors in Bayesian analysis.
6. Explain Schwarz Criterion.
7. Compare process noise and measurement noise in Kalman Filter.
8. Write the algorithm for GH filter design.
9. Write a python code to compute relative error in the true value of  $\pi$ .
10. Compare Nonlinear and Linear filters.

## PART B

Answer any one question from each module. Each question carries 14 marks

### Module I

11. a) Assume that you have a dataset with 100 data points of Gaussian distribution with a mean of 13 and standard deviation of 1.5. Using PyMC3, write Python code to compute:
- The posterior distribution
  - The prior distribution
  - The posterior predictive distribution
- (8)
- b) Write a python code to find the Bayesian credible interval in the above question. How is it different from confidence interval. (6)
12. a) Write a python code to evaluate the statistical correlation between variables in a  $5 \times 5$  Gaussian random dataset. (8)
- b) Show that  $\mathcal{N}(x | \mu, \Sigma)$  for known  $\Sigma$  is of an exponential form and that its conjugate prior is also Gaussian. (6)

### Module II

13. a) Consider the linear model  $y=ax+b$  sampled from a probability distribution
- $$y = N(ax + b, \sigma^2)$$
- Use pymc3, write a python code to estimate the parameters a,b and  $\sigma$ . (8)
- b) Assume that  $x_n, n = 1, 2, \dots, N$ , are i.i.d. observations from a Gaussian distribution  $N(\mu, \sigma^2)$  Obtain the MAP estimate of  $\mu$ , if the prior follows the exponential distribution
- $$p(\mu) = \lambda \exp(-\lambda\mu), \quad \lambda > 0, \mu \geq 0.$$
- (6)
14. a) Write a python code to generate random dataset using a noisy linear process with intercept1 , slope 2 and noise variance of 0.5. Simulate 100 data points and write a code to fit a linear regression to the data. (8)
- b) Write the steps involved in multiple linear regression technique. (6)

### Module III

15. a) Write a python code to estimate the mean and standard deviation of a randomly generated gaussian data using SMC method in pymc3. (7)
- b) Explain how posterior predictive checks are used in validating a model using pymc3. (7)

16. a) Consider the linear model

$$y = \alpha + \beta x$$

sampled from a probability distribution

$$y \sim N(\alpha + \beta x, \epsilon).$$

Use PyMC3 to write a Python code to estimate the best values of  $\alpha$  and  $\beta$  using a Bayesian Linear Regression model. (7)

- b) Explain the steps involved in calculating Bayes factor in pymc3. (7)

#### Module IV

17. Design an algorithm using Kalman filter to track a constant velocity aircraft in one dimension. (14)

18. Design an algorithm using Kalman filter to track an accelerating aircraft in one dimension. (14)

#### Module V

19. Describe the essential steps in the derivation of the Particle filter. (14)

20. Explain Multivariate Kalman Filter algorithm. (14)

# **MAR ATHANASIUS COLLEGE OF ENGINEERING**

Government Aided, Autonomous Institution, Kothamangalam, Kerala,  
India



**B.Tech**  
**Electronics And Communication  
Engineering**

## **SEMESTER 6**

### **SYLLABUS**



**SEMESTER 6**

| SLOT         | COURSE NO. | COURSES                       | L-T-P-S | HOURS     | CREDIT    |
|--------------|------------|-------------------------------|---------|-----------|-----------|
| A            | B24EC3T06  | Electromagnetic Theory        | 3-1-0-5 | 4         | 4         |
| B            | B24EC3T07  | Machine Learning              | 3-1-0-5 | 4         | 4         |
| C            | B24EC3T08  | Power Electronics             | 3-1-0-5 | 4         | 4         |
| D            | B24EC3T09  | Wireless Communication        | 3-1-0-5 | 4         | 4         |
| E            | B24EC3P2X  | Programme Elective II         | 2-1-0-4 | 3         | 3         |
| F            | B24EC3G1X  | Open Elective I               | 2-1-0-4 | 3         | 3         |
| G            | B24EC3L09  | Digital Signal Processing Lab | 0-0-3-2 | 3         | 2         |
| H            | B24EC3L10  | Mini Project                  | 0-0-3-2 | 3         | 2         |
| M            | B24ECM6X   | Minor                         | 3-1-0-5 | 4         | 4         |
| N            | B24ECH6X   | Honours                       | 3-1-0-5 | 4         | 4         |
| <b>TOTAL</b> |            |                               |         | <b>36</b> | <b>26</b> |

**PROGRAMME ELECTIVE II**

| COURSE NO | Courses                      |
|-----------|------------------------------|
| B24EC3P21 | Data Structures              |
| B24EC3P22 | Mechatronics                 |
| B24EC3P23 | Modern Communication Systems |
| B24EC3P24 | Internet Of Things           |
| B24EC3P25 | Arm System Architecture      |

**OPEN ELECTIVE I**

| COURSE NO | Courses                           |
|-----------|-----------------------------------|
| B24EC3G11 | Renewable Energy Systems          |
| B24EC3G12 | Scientific Computing Using Python |
| B24EC3G13 | Power Electronics                 |
| B24EC3G14 | VLSI Design                       |
| B24EC3G15 | Embedded Systems                  |

**MINOR**

| COURSE NO | Courses                         |
|-----------|---------------------------------|
| B24ECM61  | VLSI Circuits                   |
| B24ECM62  | Data Networks                   |
| B24ECM63  | Introduction To Computer Vision |

**HONOURS**

| COURSE NO | Courses                                |
|-----------|----------------------------------------|
| B24ECH61  | Electronic Design And Automation Tools |

|          |                                          |
|----------|------------------------------------------|
| B24ECH62 | MIMO And Multiuser Communication Systems |
| B24ECH63 | Detection And Estimation Theory          |



| B24EC3T06 | ELECTROMAGNETIC THEORY | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|------------------------|---|---|---|---|--------|----------------------|
|           |                        | 3 | 1 | 0 | 5 |        |                      |

### Preamble

This course covers the fundamentals of electromagnetic theory, including vector calculus, coordinate systems, and field laws leading to Maxwell's equations and wave equations. It explores electromagnetic wave propagation, reflection, refraction, and polarization in various media, along with energy flow through the Poynting theorem. The course also includes the analysis of transmission lines, impedance matching using Smith charts, and waveguide propagation characteristics.

### Prerequisites

B24MA1T01 : LINEAR ALGEBRA AND MULTIVARIABLE CALCULUS

### Course Outcomes

After the completion of the course, the student will be able to:

|      |                                                                                                                                                                                                                 |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Understand and apply vector calculus concepts and coordinate transformations to analyze electric and magnetic fields using fundamental field laws such as Coulomb's, Gauss's, and Ampere's. [Understand, Apply] |
| CO 2 | Apply Maxwell's equations and related boundary conditions to determine field behavior, capacitance, inductance, and energy storage in various electromagnetic systems. [Apply]                                  |
| CO 3 | Analyze the propagation of electromagnetic waves in different media and evaluate parameters such as attenuation, phase velocity, and reflection/refraction characteristics. [Understand, Apply]                 |
| CO 4 | Apply Poynting's theorem to determine electromagnetic power flow and analyze transmission line behavior including impedance, reflection coefficient, and VSWR. [Apply]                                          |
| CO 5 | Use Smith charts and waveguide theory to analyze impedance matching, propagation modes, and wavelength relationships in guided electromagnetic systems. [Understand, Apply]                                     |

### Mapping of Course Outcomes With Program Outcomes

### Assessment Pattern

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 3    |      |      |      |      |      |      |      |       | 2     |
| CO 2 | 3    | 3    |      |      | 2    |      |      |      |      |       | 2     |
| CO 3 | 3    | 2    |      |      |      | 2    |      |      |      |       | 2     |
| CO 4 | 3    | 3    |      |      | 2    |      |      |      |      |       | 2     |
| CO 5 | 3    | 2    | 2    |      | 3    |      |      |      |      |       | 2     |

Table 30: CO–PO Correlation Matrix for *Introduction to Electromagnetic Theory*

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

**Mark Distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

**Continuous Internal Evaluation Pattern**

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

**End Semester Examination Pattern**

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## **SYLLABUS**

### **MODULE 1**

Introduction to Electromagnetic Theory: Review of vector calculus- curl, divergence, gradient. Rectangular, cylindrical and spherical coordinate systems, Co-ordinate transformations. Divergence theorem- Stokes theorem, Expression of curl, divergence and Laplacian in Cartesian, cylindrical and spherical coordinate system. Electric field and magnetic field, Review of Coulomb's law, Gauss law and Amperes current law. Poisson and Laplace equations, Determination of E and V using Laplace equation.

### **MODULE 2**

Derivation of capacitance and inductance of two wire transmission line and coaxial cable. Energy stored in Electric and Magnetic field. Displacement current density, continuity equation. Maxwell's equation from fundamental laws. Boundary condition of electric field and magnetic field from Maxwells equations. Solution of wave equation.

### **MODULE 3**

Propagation of plane EM wave in perfect dielectric, lossy medium, good conductor, media attenuation, phase velocity, group velocity, skin depth. Reflection and refraction of plane electromagnetic waves at boundaries for normal & oblique incidence (parallel and perpendicular polarization), Snell's law of refraction, Brewster angle.

### **MODULE 4**

Power density of EM wave, Poynting vector theorem. Polarization of electromagnetic wave, linear, circular and elliptical polarization.

Uniform lossless transmission line - line parameters. Transmission line equations, Voltage and Current distribution of a line terminated with load .Reflection coefficient and VSWR. Derivation of input impedance of transmission line.

### **MODULE 5**

Transmission line as circuit elements (L and C). Development of Smith chart - calculation of line impedance and VSWR using smith chart.

Hollow rectangular wave guide –modes of propagation of wave-dominant mode, group velocity and phase velocity -derivation and simple problems only, relation between guide wave length, cutoff wave length and free space wave length.

**Text Books**

1. Matthew N. O. Sadiku, Elements of Electromagnetics, 7th Edition, Oxford University Press, 2018.
2. William H. Hayt and John A. Buck, Engineering Electromagnetics, 9th Edition, McGraw-Hill Higher Education, 2019.
3. Mahmood Nahvi and Joseph Edminister, Schaum's Outline of Electromagnetics, 5th Edition, McGraw-Hill, 2019.
4. Jordan and Balmain , Electromagnetic waves and Radiating Systems, PHI, 2/e,2013





**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                                                                                   | No of Lecture/Tutorial Hours |
|-----|-------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                         | <b>10</b>                    |
| 1.1 | Review of vector calculus – gradient, divergence, and curl. Rectangular, cylindrical, and spherical coordinate systems. | 2                            |
| 1.2 | Coordinate transformations, Divergence theorem, and Stokes theorem.                                                     | 2                            |
| 1.3 | Expression of curl, divergence, and Laplacian in Cartesian, cylindrical, and spherical coordinates.                     | 2                            |
| 1.4 | Electric and magnetic fields – review of Coulomb’s law, Gauss’s law, and Ampere’s current law.                          | 2                            |
| 1.5 | Poisson’s and Laplace’s equations, determination of electric field (E) and potential (V) using Laplace’s equation.      | 2                            |
|     | <b>Module 2</b>                                                                                                         | <b>9</b>                     |
| 2.1 | Derivation of capacitance and inductance of two-wire transmission line and coaxial cable.                               | 2                            |
| 2.2 | Energy stored in electric and magnetic fields, displacement current density, and continuity equation.                   | 2                            |
| 2.3 | Maxwell’s equations derived from fundamental laws.                                                                      | 2                            |
| 2.4 | Boundary conditions for electric and magnetic fields from Maxwell’s equations.                                          | 2                            |
| 2.5 | Solution of the electromagnetic wave equation.                                                                          | 1                            |
|     | <b>Module 3</b>                                                                                                         | <b>9</b>                     |
| 3.1 | Propagation of plane electromagnetic waves in perfect dielectrics, lossy media, and good conductors.                    | 2                            |
| 3.2 | Attenuation constant, phase velocity, group velocity, and skin depth.                                                   | 2                            |
| 3.3 | Reflection and refraction of plane electromagnetic waves at normal incidence.                                           | 2                            |
| 3.4 | Oblique incidence (parallel and perpendicular polarization), Snell’s law and Brewster’s angle.                          | 3                            |
|     | <b>Module 4</b>                                                                                                         | <b>8</b>                     |
| 4.1 | Power density of electromagnetic waves and the Poynting vector theorem.                                                 | 2                            |
| 4.2 | Polarization of electromagnetic waves – linear, circular, and elliptical polarization.                                  | 2                            |
| 4.3 | Uniform lossless transmission line – parameters, voltage and current distribution, and reflection coefficient.          | 2                            |
| 4.4 | Voltage Standing Wave Ratio (VSWR) and input impedance of transmission lines.                                           | 2                            |
|     | <b>Module 5</b>                                                                                                         | <b>9</b>                     |
| 5.1 | Transmission line as circuit elements (L and C), development of Smith chart.                                            | 2                            |

|     |                                                                                          |                 |
|-----|------------------------------------------------------------------------------------------|-----------------|
| 5.2 | Calculation of line impedance and VSWR using Smith chart.                                | 2               |
| 5.3 | Rectangular waveguide – modes of propagation, dominant mode, group and phase velocities. | 3               |
| 5.4 | Relation between guide wavelength, cutoff wavelength, and free-space wavelength.         | 2               |
|     | <b>Total Hours</b>                                                                       | <b>45 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain and derive the expressions for divergence, curl, and gradient in Cartesian coordinates.
2. Derive poisson and Laplace equation.

#### Course Outcome 2 (CO 2):

1. Derive Maxwell's equations from fundamental laws and explain the significance of each term.
2. Derive the capacitance and inductance of a two-wire transmission line.

#### Course Outcome 3 (CO 3):

1. Derive the expression for wave propagation in a lossy medium and explain the meaning of attenuation and phase velocity.
2. Explain the reflection and refraction of plane electromagnetic waves at a boundary between two dielectrics, when the uniform plane wave is incident normal to the interface.

#### Course Outcome 4 (CO 4):

1. State and prove the Poynting theorem and discuss its physical significance.
2. Derive the transmission line equations and obtain expressions for voltage and current distribution along the line.

**Course Outcome 5 (CO 5):**

1. Explain how the Smith chart is used to determine the impedance and VSWR of a transmission line.
2. Derive the expressions for cutoff wavelength and propagation constant of a rectangular waveguide, and explain the dominant mode.



MODEL QUESTION PAPER

QP CODE:

Pages: 5

Reg.No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027

Course Code: B24EC3T06

Course Name: ELECTROMAGNETIC THEORY

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. A circular cylinder of radius  $r = 5$  cm is concentric with the  $z$ -axis and extends between  $z = -3$  cm and  $3$  cm. Find the volume of the cylinder
2. Express Maxwell's equations for time varying field in point form.
3. Write all equations for transforming a vector field from cylindrical to rectangular coordinates.
4. Derive the expression for the inductance of a co-axial cable.
5. State Brewster's law. Calculate the Brewster angle for a quartz of dielectric constant 2.3
6. What is meant by uniform plane waves? Also, why are electromagnetic waves called as transverse electromagnetic waves?
7. Differentiate elliptical and circular polarisation.
8. Define Standing wave ratio and explain the relation with reflection co-efficient of a transmission line.
9. A transmission line has a characteristic impedance of  $50\Omega$  and a resistance of  $0.1\Omega/\text{m}$ . If the line is distortion less, find the attenuation constant (in  $\text{Np/m}$ ) is
10. Describe how line section of a transmission line is used as circuit elements in high frequency applications.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain Gauss Law and State Divergence theorem. (4)  
b) Find the total electric flux  $\oint \mathbf{E} \cdot d\mathbf{A}$  through the surface of a cube with side length  $a$  centered at the origin considering the electric field  $\mathbf{E}$  given by the expression  $\mathbf{E} = 2x^2\hat{a}_x + 3y\hat{a}_y - 4z\hat{a}_z$  (7)
12. a) A spherical volume of radius  $a$  contains a uniform volume charge density  $\rho_v$ . Use Gauss's law to determine  $D$  for (a)  $R \leq a$  and (b)  $R \geq a$ . (10)  
b) Given  $V = x^2y + xy^2 + xz^2$ , (a) find the gradient of  $V$ , and (b) evaluate it at  $(1, -1, 2)$  (4)

**Module II**

13. a) Derive the expression for energy stored in a charge distribution and hence in an electric field (7)  
b) Derive the boundary conditions of static magnetic field at the interface of two different magnetic medium. (7)
14. a) Derive the expression for equation of continuity. Describe how Ampere's law is modified by the equation of continuity. (7)  
b) Define capacitance. Determine the capacitance of a two-wire transmission line. (7)

**Module III**

15. a) Derive the expression for Brewster angle for parallel polarised wave. (7)  
b) A 10-MHz uniform plane wave is travelling in a nonmagnetic medium with  $\mu = \mu_0$  and  $\epsilon_r = 9$ . Find (a) the phase velocity, (b) the wave number, (c) the wavelength in the medium, and (d) the intrinsic impedance of the medium. (7)
16. a) Derive the equation for transmission and reflection coefficients of an electromagnetic wave incident normally on the boundary between two different regions. (8)  
b) The electric field of a traveling electromagnetic wave is given by  $E(z, t) = 10\cos(\pi \times 10^7 t + \pi z/15 + \pi/6)$  (V/m). Determine (a) the direction of wave propagation, (b) the wave frequency  $f$ , (c) its wavelength  $\lambda$ , and (d) its phase velocity (6)

**Module IV**

17. a) Derive an expression for net outward power flow associated with an electromagnetic wave, from a surface. (10)
- b) A  $50\text{-}\Omega$  lossless line is terminated in a load impedance  $Z_L = (30 - j20)\Omega$ . Calculate  $\Gamma$  and  $S$  (4)
18. a) Derive the expression of input impedance due to a transmission line terminated by a load  $Z_L$  (7)
- b) The propagation constant of a lossy transmission line is  $(1 + 2j)m^{-1}$  and its characteristic impedance is  $100\Omega$  at  $\omega = 10^6$  rad/sec. What are the values of L, C, R and G? (7)

**Module V**

19. a) A  $50 + j75\Omega$  load is connected to  $100\Omega$  lossless line. Using smith chart find (i) Reflection coefficient (ii) Standing Wave Ratio (iii) The load admittance  $Y_L$  (iv)  $Z_{in}$  at  $0.5\lambda$  from the load. (10)
- b) A rectangular waveguide of internal dimensions ( $a = 4\text{cm}$  and  $b = 3\text{cm}$ ) is to be operated in  $TE_{11}$  mode. Find the minimum operating frequency (4)
20. Derive expression for TE mode in rectangular wave guide.



| B24EC3T07 | MACHINE<br>LEARNING | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|---------------------|---|---|---|---|--------|-------------------------|
|           |                     | 3 | 1 | 0 | 5 | 4      | 2024                    |

### Preamble

This course introduces the fundamental principles, algorithms and methodologies to build data-driven models capable of intelligent decision-making. Emphasizes both supervised and unsupervised learning approaches, including regression, classification, clustering, ensemble methods, dimensionality reduction, and real-world applications such as image, text, and fraud detection

### Prerequisites

Basic knowledge of linear algebra, probability theory and statistics

### Course Outcomes

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                                 |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the basics of machine learning and different types along with the probability theory for building the model. [Understand]                                            |
| <b>CO 2</b> | Understand the concept of regression, classification, Bayes' decision theory, Naïve Bayes Classifier and apply these in real world applications. [Understand, Apply]            |
| <b>CO 3</b> | Understand linear algebra and statistical methods in discriminant based algorithms in supervised learning and apply these concepts in image classification. [Understand, Apply] |
| <b>CO 4</b> | Understand the basics of unsupervised learning and non-metric methods. [Understand, Apply]                                                                                      |
| <b>CO 5</b> | Understand ensemble methods, dimensionality reduction, evaluation, model selection. [Understand, Apply]                                                                         |

### Mapping of Course Outcomes With Program Outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    |      |      |      |      |      |      |      |      |       |       |
| <b>CO 2</b> | 3    | 3    | 3    | 3    | 3    |      |      |      |      |       |       |
| <b>CO 3</b> | 3    | 3    | 3    | 3    | 3    | 3    |      |      |      |       |       |
| <b>CO 4</b> | 3    |      |      |      |      |      |      |      |      |       |       |
| <b>CO 5</b> | 3    |      |      | 3    | 3    | 3    |      |      |      |       |       |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 30                    | 30                 | 30                                    |
| Apply            | 50                    | 50                 | 50                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Introduction to Machine Learning:** Basics of machine learning, supervised and unsupervised learning, real-world applications in image, text and IoT domains, features, feature vector, training set, target vector, test set, feature extraction, overfitting, curse of dimensionality, Introduction to Generative AI, Review of probability theory, Gaussian distribution, decision theory.

### MODULE 2

**Regression and Classification Techniques:** Data Cleaning and Transformation: Handling missing data, Normalizing and standardizing, Outlier detection and treatment, Linear regression, error functions in regression, multivariate regression, regression applications, bias and variance. Classification: Bayes' decision theory-conceptual overview, Naïve Bayes Classifier – Concept and Real world Applications.

### MODULE 3

**Supervised learning:** Linear discriminant based algorithm, gradient descent method, support vector machines, separable classes, non-separable classes, multiclass case, Model Tuning and Hyperparameter Optimization, Artificial Neural Network: Introduction, Perceptrons, multi-layer networks, Basic architecture of CNN, Activation functions in CNN, Introduction to popular CNN models, Case study : Implementation of image classification problems.

### MODULE 4

**Unsupervised Learning:** Clustering, examples, Association Rule Mining, criterion functions for clustering, proximity measures, algorithms for clustering: Hierarchical clustering, k-Means clustering, DBSCAN clustering. Ensemble methods: boosting, bagging. Decision trees, random forest- concept and application.

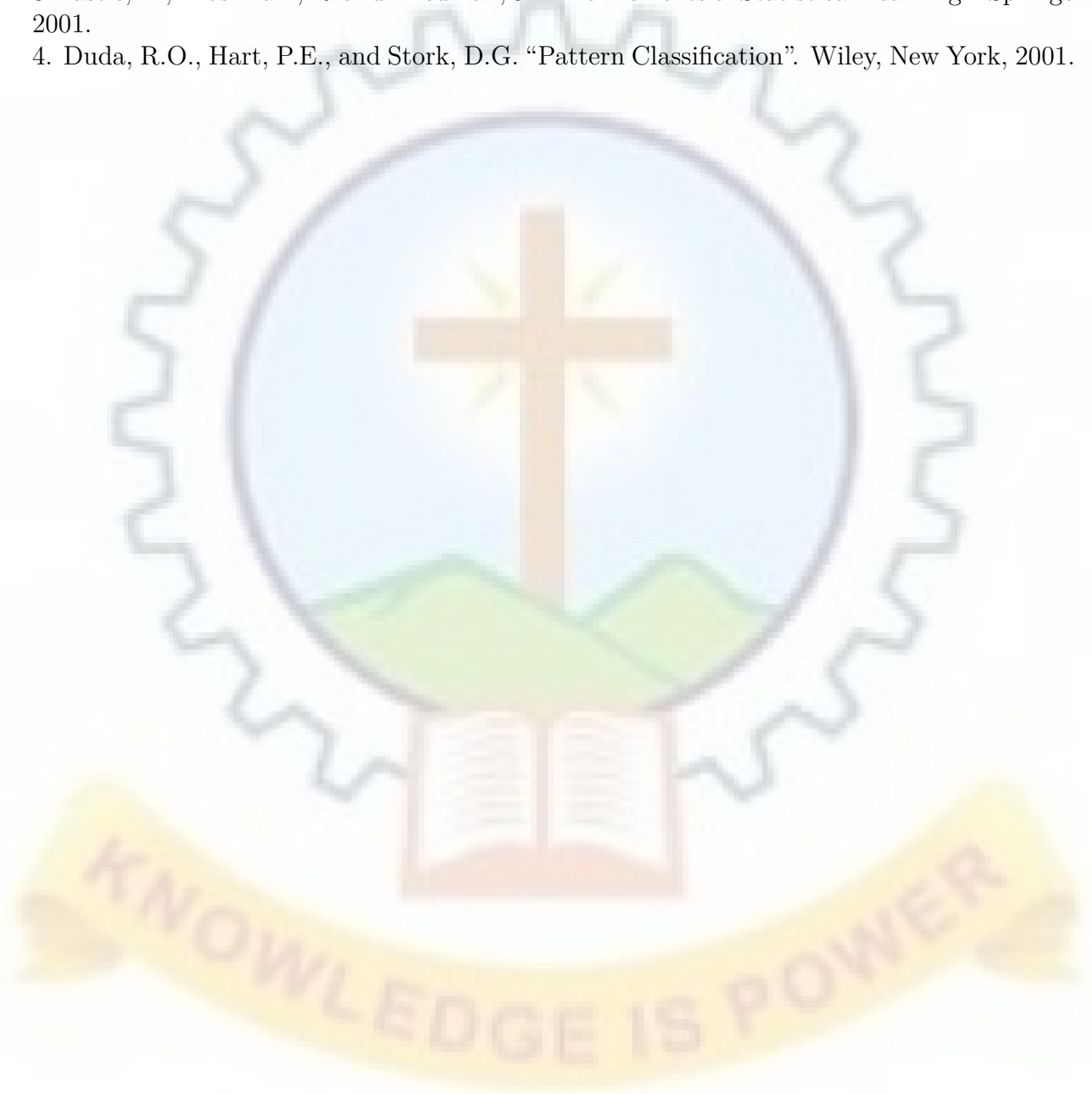
### MODULE 5

**Evaluation and model Selection:** Dimensionality reduction: principal component analysis, Fischer's discriminant analysis. Evaluation and model Selection: ROC curves, evaluation measures, validation set, bias- variance trade-off. Confusion matrix, recall, precision, accuracy. Case study : comparative analysis of models based on precision-recall -trade-offs for

spam detection.

**Text Books**

1. Bishop, C. M. "Pattern Recognition and Machine Learning" Springer, New York, 2006.
2. Theodoridis, S. and Koutroumbas, K. "Pattern Recognition". Academic Press, San Diego, 2003.
3. Hastie, T., Tibshirani, R. and Friedman, J. "The Elements of Statistical Learning". Springer. 2001.
4. Duda, R.O., Hart, P.E., and Stork, D.G. "Pattern Classification". Wiley, New York, 2001.



**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                            | <b>No of Lecture/Tutorial Hours</b> |
|-----------|-------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                                         | <b>8</b>                            |
| 1.1       | Basics of machine learning, supervised and unsupervised learning                                                        | 1                                   |
| 1.2       | Real-world applications in image, text and IoT domains, features, feature vector                                        | 1                                   |
| 1.3       | Training set, target vector, test set, feature extraction, overfitting                                                  | 2                                   |
| 1.4       | Curse of dimensionality, Introduction to Generative AI                                                                  | 1                                   |
| 1.5       | Review of probability theory, Gaussian distribution, decision theory                                                    | 3                                   |
|           | <b>Module 2</b>                                                                                                         | <b>10</b>                           |
| 2.1       | Data Cleaning and Transformation: Handling missing data, Normalizing and standardizing, Outlier detection and treatment | 2                                   |
| 2.2       | Linear regression, error functions in regression                                                                        | 1                                   |
| 2.3       | multivariate regression, regression applications                                                                        | 1                                   |
| 2.4       | bias and variance                                                                                                       | 1                                   |
| 2.5       | Classification: Bayes' decision theory-conceptual overview                                                              | 2                                   |
| 2.6       | Naïve Bayes Classifier- Concept and Real world Applications .                                                           | 3                                   |
|           | <b>Module 3</b>                                                                                                         | <b>10</b>                           |
| 3.1       | Linear discriminant based algorithm                                                                                     | 1                                   |
| 3.2       | Gradient descent method and Support vector machines                                                                     | 3                                   |
| 3.3       | Separable classes, non-separable classes, multiclass case                                                               | 1                                   |
| 3.4       | Model Tuning and Hyperparameter Optimization                                                                            | 1                                   |
| 3.5       | Artificial Neural Network: Introduction, Perceptrons, multi-layer networks                                              | 1                                   |
| 3.6       | Basic architecture of CNN, Activation functions in CNN, Introduction to popular CNN models                              | 2                                   |
| 3.7       | Implementation of image or text classification problems                                                                 | 1                                   |
|           | <b>Module 4</b>                                                                                                         | <b>9</b>                            |
| 4.1       | Clustering, examples, Association Rule Mining                                                                           | 1                                   |
| 4.2       | Criterion functions for clustering                                                                                      | 1                                   |
| 4.3       | Proximity measures.                                                                                                     | 1                                   |
| 4.4       | Algorithms for clustering: Hierarchical clustering and k-means clustering, DBSCAN clustering                            | 2                                   |
| 4.5       | Ensemble methods: boosting, bagging.                                                                                    | 1                                   |
| 4.6       | Decision trees, random forest- concept and application.                                                                 | 3                                   |
|           | <b>Module 5</b>                                                                                                         | <b>8</b>                            |
| 5.1       | Dimensionality reduction: principal component analysis                                                                  | 1                                   |

|     |                                                                                                           |                 |
|-----|-----------------------------------------------------------------------------------------------------------|-----------------|
| 5.2 | Fischer's discriminant analysis                                                                           | 1               |
| 5.3 | Evaluation and model Selection: ROC curves, evaluation measures, validation set, bias- variance trade-off | 4               |
| 5.4 | Confusion matrix, recall, precision, accuracy                                                             | 1               |
| 5.5 | Case study : comparative analysis of models based on precision-recall -trade-offs for spam detection      | 1               |
|     | <b>Total Hours</b>                                                                                        | <b>45 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Differentiate supervised and unsupervised learning using examples.
2. Understand different terms and methods used in machine learning.

#### Course Outcome 2 (CO 2):

1. Differentiate regression and classification using examples.
2. To apply Bayes' decision theory in classification for normal distributions.

#### Course Outcome 3 (CO 3):

1. Use statistical methods to obtain perceptron algorithm.
2. Use support vector machines for separable classes and non separable classes.

#### Course Outcome 4 (CO 4):

1. Explain unsupervised learning with examples.
2. Differentiate boosting and bagging.

#### Course Outcome 5 (CO 5):

1. Describe Principal component analysis, Fischer's discriminant analysis.
2. Explain ROC curves, evaluation measures, validation set, bias-variance trade-off.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 2**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24EC3T07**

**Course Name: MACHINE LEARNING**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Explain machine learning with examples.
2. Explain over-fitting in machine learning.
3. Explain regression with examples.
4. State Bayes decision theory.
5. Sketch a simple perceptron model.
6. Discuss how SVM is used for multiclass problem.
7. Explain clustering with examples.
8. Explain decision trees with examples.
9. Explain ROC curves.
10. Explain bias-variance trade-off.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain the terms features, training set, target vector, and test set. (7)  
b) Distinguish supervised and unsupervised machine learning with examples. (7)
12. a) Explain a multi-variate Gaussian distribution along with its parameters. (7)  
b) Explain curse of dimensionality in machine learning. (7)

**Module II**

13. a) You are given a small 2-class dataset with two features (e.g., height and weight). Explain how you would implement the perceptron learning algorithm to classify the samples. Show the steps of weight initialization, calculating prediction, updating weights and stopping when all samples are correctly classified. (10)  
b) Describe the concept of gradient descent. Why is it used in training linear classifiers? (4)
14. a) Show that the Bayesian classifier is optimal with respect to minimizing the classification error probability. (7)  
b) Obtain the decision surface for an equi-probable two class system, where the probability density functions of 1-dimensional feature vectors in both classes are normally distributed. (7)

**Module III**

15. a) Explain how perceptron algorithm applied in classification. (7)  
b) Explain the significance of gradient descent method in machine learning algorithms. (7)
16. a) Obtain the cost function for optimization in SVM for separable classes. (7)  
b) Explain how SVM is used in non-separable classes. (7)

**Module IV**

17. a) Explain different criterion functions for clustering. (7)  
b) Give a description of different clustering algorithms. (7)
18. a) Explain different ensemble methods in classification. (7)  
b) Illustrate random forest algorithm. (7)

**Module V**

19. a) Explain the significance of dimensionality reduction in machine learning. (4)  
b) Apply Fisher's Discriminant Analysis to a two-class dataset and demonstrate how the projection direction is computed. Explain how the new 1-D feature is used to classify the samples. (10)
20. a) How performance evaluation and model selection is done in machine learning. (7)  
b) Explain confusion matrix, recall, precision and accuracy. (7)

| B24EC3T08 | POWER<br>ELECTRONICS | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|----------------------|---|---|---|---|--------|-------------------------|
|           |                      | 3 | 1 | 0 | 5 | 4      | 2024                    |

**Preamble**

This course provides a comprehensive understanding of modern power electronic devices, converter topologies, and control techniques essential for renewable energy systems, electric mobility, and embedded industrial applications.

**Prerequisites**

ANALOG CIRCUITS 1 (B24EC1T04)

**Course Outcomes**

|             |                                                                                                                                                    |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Explain the characteristics, switching behavior, and application suitability of Si, SiC, and GaN power semiconductor devices. [Understand, Apply]  |
| <b>CO 2</b> | Design and analyze DC-DC converters (linear, LDO, and switching types) for efficiency, regulation, and ripple performance. [Understand, Apply]     |
| <b>CO 3</b> | Evaluate inverter and rectifier topologies with appropriate modulation and protection strategies for power conversion systems. [Understand, Apply] |
| <b>CO 4</b> | Apply motor drive control concepts (V/f, BLDC, PMSM) using suitable gate drivers, sensors, and protection circuits. [Understand, Apply]            |
| <b>CO 5</b> | Integrate digital control, EMI/EMC compliance, and safety considerations in the design of reliable power electronic systems. [Understand, Apply]   |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 2    | 1    | 1    | 2    | 2    |      |      |      | 1     | 2     |
| <b>CO 2</b> | 3    | 3    | 3    | 2    | 3    | 2    | 1    |      |      | 2     | 2     |
| <b>CO 3</b> | 3    | 3    | 3    | 2    | 3    | 2    | 1    |      |      | 2     | 2     |
| <b>CO 4</b> | 3    | 2    | 3    | 3    | 3    | 2    |      |      | 2    | 2     | 2     |
| <b>CO 5</b> | 3    | 2    | 3    | 3    | 3    | 3    | 2    |      | 2    | 3     | 2     |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 30                    | 30                 | 30                                    |
| Apply            | 50                    | 50                 | 50                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions carrying 3 marks each. Part B contains 2 questions from each module out of which 1 to be answered. Each question carries 14 mark and can have maximum 2 sub- divisions.

## SYLLABUS

### MODULE 1 (9 hours)

**Fundamentals & Semiconductor Devices:** Role of power electronics in modern systems — renewable energy, EVs, robotics, data centers. Power semiconductor families: Si, SiC, GaN - structure, switching characteristics, and selection criteria. Power diode, MOSFET, and IGBT — static and dynamic characteristics. Gate driving concepts: level shifting, isolation, bootstrap drivers. Snubber design and EMI considerations. Thermal management and datasheet interpretation (IRF540N, C3M0065100K, GS66508T, FGH60N60SFD, MUR460, C3D06060A).

### MODULE 2 ( 9 hours)

**DC-DC Converters:** Principle of operation of series regulators and Low Dropout Regulators (LDOs): internal architecture, Concept of switching regulators; comparison with linear regulators. Buck, Boost, Buck-Boost converters — operating principles, waveforms, and design equations. Continuous and discontinuous conduction modes. Design of LC filter, current ripple estimation. Introduction to synchronous rectification and digital control (using microcontrollers/FPGAs). IC controller: MC34063.

### MODULE 3 ( 9 hours)

**DC-AC and AC-DC Converters:** Full-bridge and half-bridge inverters; SPWM. Introduction to three-phase inverters, Rectifiers: single- and three-phase, active PFC concept. Grid-connected inverters, anti-islanding protection. Bidirectional converters for battery systems.

### MODULE 4 (9 hours)

**Motor Drives & Applications:** Overview of electrical drives — DC, BLDC, PMSM, induction motor control (V/f). Gate driver isolation, current sensing, and protection in motor drives. Regenerative braking. Typical ICs used in power converter applications: STM32G431, UCC21520, ACS71240.

### MODULE 5 (10 hours)

**Design, Control & Emerging Technologies:** Digital control loop basics (PWM generation, current/voltage feedback). FPGA/Microcontroller-based control architectures. Design case study: Solar MPPT converter, EV motor inverter, SMPS for embedded system, EMI/EMC compliance and PCB layout for power electronics. Industry trends: SiC/GaN converters, wireless power. Safety standards and reliability testing.

**Text Books**

1. Umanand L, Power Electronics: Essentials & Applications, Wiley India, 2015
2. Ned Mohan et al., Power Electronics: Converters, Applications, and Design, Wiley.
3. Bimal K. Bose, Modern Power Electronics and AC Drives, Pearson.
4. Rashid, Power Electronics: Circuits, Devices and Applications, Pearson.





**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                                                                      | No of Lecture/Tutorial Hours |
|-----|------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1 — Fundamentals &amp; Semiconductor Devices</b>                                                 | <b>9</b>                     |
| 1.1 | Role of power electronics in modern systems — renewable energy, EVs, robotics, data centers.               | 1                            |
| 1.2 | Power semiconductor families: Si, SiC, GaN — structure, switching characteristics, and selection criteria. | 2                            |
| 1.3 | Power diode, MOSFET, and IGBT — static and dynamic characteristics.                                        | 2                            |
| 1.4 | Gate driving concepts: level shifting, isolation, bootstrap drivers.                                       | 1                            |
| 1.5 | Snubber design, EMI considerations, and thermal management.                                                | 2                            |
| 1.6 | Datasheet interpretation and comparison (IRF540N, C3M0065100K, GS66508T, FGH60N60SFD, MUR460, C3D06060A).  | 1                            |
|     | <b>Module 2 — DC–DC Converters</b>                                                                         | <b>9</b>                     |
| 2.1 | Principle of operation of series regulators and Low Dropout Regulators (LDOs): internal architecture.      | 1                            |
| 2.2 | Concept of switching regulators; comparison with linear regulators.                                        | 1                            |
| 2.3 | Buck, Boost, Buck–Boost converters — operation, waveforms, and design equations.                           | 3                            |
| 2.4 | Continuous and discontinuous conduction modes, LC filter design, and current ripple estimation.            | 2                            |
| 2.5 | Synchronous rectification, digital control (microcontrollers/FPGAs), and IC controller MC34063.            | 2                            |
|     | <b>Module 3 — DC–AC and AC–DC Converters</b>                                                               | <b>9</b>                     |
| 3.1 | Full-bridge and half-bridge inverters; sinusoidal PWM (SPWM).                                              | 2                            |
| 3.2 | Introduction to three-phase inverters — principle of operation and control.                                | 2                            |
| 3.3 | Rectifiers: single- and three-phase, active PFC concept.                                                   | 2                            |
| 3.4 | Grid-connected inverters and anti-islanding protection.                                                    | 2                            |
| 3.5 | Bidirectional converters for battery systems.                                                              | 1                            |
|     | <b>Module 4 — Motor Drives &amp; Applications</b>                                                          | <b>9</b>                     |
| 4.1 | Overview of electrical drives — DC, BLDC, PMSM, induction motor control (V/f).                             | 3                            |
| 4.2 | Gate driver isolation, current sensing, and protection in motor drives.                                    | 2                            |
| 4.3 | Regenerative braking and energy recovery principles.                                                       | 2                            |

|     |                                                                                                         |                 |
|-----|---------------------------------------------------------------------------------------------------------|-----------------|
| 4.4 | Typical ICs used in power converter applications: STM32G431, UCC21520, ACS71240.                        | 2               |
|     | <b>Module 5 — Design, Control &amp; Emerging Technologies</b>                                           | <b>9</b>        |
| 5.1 | Digital control loop basics: PWM generation, current/voltage feedback.                                  | 2               |
| 5.2 | FPGA/Microcontroller-based control architectures.                                                       | 2               |
| 5.3 | Design case studies: Solar MPPT converter, EV motor inverter, SMPS for embedded system.                 | 2               |
| 5.4 | EMI/EMC compliance, PCB layout design for power converters.                                             | 2               |
| 5.5 | Industry trends: SiC/GaN converters, wireless power transfer, safety standards and reliability testing. | 1               |
|     | <b>Total Hours</b>                                                                                      | <b>45 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the role of power electronics in modern applications such as renewable energy systems, electric vehicles, and robotics. Discuss how advancements in semiconductor materials (Si, SiC, GaN) have impacted converter efficiency and performance.
2. Compare the static and dynamic characteristics of a power MOSFET and IGBT using datasheets (e.g., IRF540N, FGH60N60SFD). Illustrate how switching speed and thermal parameters influence device selection for a 500 W DC–DC converter.

#### Course Outcome 2 (CO 2):

1. Design a 12 V to 5 V buck converter operating at 100 kHz and 2 A load current. Calculate the required inductor, output capacitor, and diode ratings. Sketch the waveforms of inductor current and switch voltage for CCM and DCM operation.
2. Compare Buck, Boost, and Buck–Boost converters in terms of voltage conversion ratio, efficiency, and ripple. Explain how synchronous rectification and digital control (using microcontrollers or FPGAs) improve converter performance.

#### Course Outcome 3 (CO 3):

1. Derive the output voltage equation and modulation index for a single-phase full-bridge inverter using sinusoidal PWM. Plot the waveform and explain how harmonic content varies with modulation index.
2. Discuss the operation of single-phase and three-phase rectifiers with input filters. Design an active PFC circuit for a 230 V AC input, 400 V DC output converter and describe its control strategy.

**Course Outcome 4 (CO 4):**

1. Explain the principle of V/f control for a three-phase induction motor. Draw the block diagram and describe how PWM-based voltage control can be implemented using an STM32G431 microcontroller.
2. Design a gate driver and current-sensing circuit for a BLDC motor inverter using UCC21520 and ACS71240. Include protection features such as shoot-through prevention and overcurrent shutdown.

**Course Outcome 5 (CO 5):**

1. Design a digitally controlled MPPT converter for a 200 W solar panel. Explain the algorithm (Perturb & Observe or Incremental Conductance), and describe how feedback signals are processed in an embedded controller.
2. Discuss PCB layout techniques for minimizing EMI/EMC in power converter design. Suggest design improvements to meet reliability and safety standards for an industrial DC-AC inverter.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 3**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SIXTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2024**

**Course Code: B24EC3T08**

**Course Name: POWER ELECTRONICS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 4 marks**

1. Explain the significance of power electronics in renewable energy and electric vehicle applications.
2. Compare the characteristics of Si, SiC, and GaN semiconductor devices.
3. Define and differentiate between static and dynamic characteristics of power devices.
4. What are the common gate driver isolation methods used for MOSFETs and IGBTs?
5. Explain the function of a snubber circuit and its importance in power converter design.
6. Compare linear regulators with switching regulators.
7. Define continuous and discontinuous conduction modes in DC–DC converters.
8. Explain the concept of sinusoidal PWM and its effect on inverter output.
9. What is the role of active power factor correction (PFC) in rectifier design?
10. Explain the principle of V/f control in induction motor drives.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Compare the switching characteristics of MOSFET and IGBT with the help of suitable diagrams. (7)  
b) Explain the working of a bootstrap driver circuit used for high-side gate drive. (7)
12. a) Discuss the effect of junction temperature on device performance and explain thermal management techniques in power converters. (7)  
b) Explain the procedure for interpreting MOSFET datasheets with suitable examples (IRF540N or GS66508T). (7)

#### **Module II**

13. a) Derive the voltage conversion ratio and current waveforms for Buck, Boost, and Buck-Boost converters. (7)  
b) Design a Buck converter to convert 12 V to 5 V at 2 A load current and 100 kHz switching frequency. Calculate L and C values. (7)
14. a) Explain the working of a synchronous buck converter and discuss its efficiency advantages. (7)  
b) Describe the internal architecture and operation of the MC34063 converter IC. (7)

#### **Module III**

15. a) Explain the operation of a single-phase full-bridge inverter using sinusoidal PWM. Derive the RMS output voltage expression. (7)  
b) Explain how harmonic reduction is achieved in inverter outputs through modulation techniques. (7)
16. a) Compare single-phase and three-phase diode bridge rectifiers with respect to output ripple and power factor. (7)  
b) Explain the concept of active PFC and draw a block diagram of a boost-type PFC circuit. (7)

#### **Module IV**

17. a) Explain the working principle of BLDC motor drive with inverter topology. Illustrate current waveforms. (7)  
b) Design a current sensing and protection circuit for motor drive using ACS71240. (7)
18. a) Discuss the regenerative braking operation in DC and BLDC drives. (7)  
b) Describe the role of STM32G431 microcontroller in closed-loop control of a motor drive system. (7)

#### **Module V**

19. a) Explain the design and implementation of an MPPT converter for a solar PV system. Discuss control algorithms used. (7)  
b) Outline EMI/EMC mitigation techniques in PCB layout for high-frequency converters. (7)
20. a) Discuss the architecture of FPGA or microcontroller-based digital control loop for a DC–DC converter. (7)  
b) Write short notes on recent trends in power electronics: SiC/GaN converters, wireless power transfer, and reliability testing. (7)





| <b>B24EC3T09</b> | <b>WIRELESS COMMUNICATION</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF INTRODUCTION</b> |
|------------------|-------------------------------|----------|----------|----------|----------|---------------|-----------------------------|
|                  |                               | 3        | 1        | 0        | 5        |               |                             |

**Preamble**

This course aims to introduce students to basic theory and principles of wireless communication systems in general, and cellular systems in particular. It also introduces basics of radio wave propagation.

**Prerequisites**

ECT 305 Analog and Digital Communication

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                    |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Calculate system parameters such antenna height, range, maximum usable frequency in different modes of radio wave propagation. [Understand, Apply] |
| <b>CO 2</b> | Summarize the basics of cellular system and cellular design fundamentals. [Understand, Apply]                                                      |
| <b>CO 3</b> | Describe the wireless channel models and discuss capacity of wireless channels. [Understand, Apply]                                                |
| <b>CO 4</b> | Analyze the performance of the modulation techniques for flat-fading channels and multicarrier modulation. [Understand, Apply]                     |
| <b>CO 5</b> | Illustrate how receiver performance can be enhanced by various diversity techniques. [Understand, Apply]                                           |

**Mapping of Course Outcomes With Program Outcomes**

|             | <b>PO 1</b> | <b>PO 2</b> | <b>PO 3</b> | <b>PO 4</b> | <b>PO 5</b> | <b>PO 6</b> | <b>PO 7</b> | <b>PO 8</b> | <b>PO 9</b> | <b>PO 10</b> | <b>PO 11</b> |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|
| <b>CO 1</b> | 3           | 3           | 2           | 1           | 2           | 1           | 1           | 2           |             | 1            | 3            |
| <b>CO 2</b> | 3           | 3           | 3           | 1           | 3           | 1           | 1           | 1           |             |              | 3            |
| <b>CO 3</b> | 3           | 3           | 3           |             | 3           | 2           | 1           | 1           | 1           | 1            | 3            |
| <b>CO 4</b> | 3           | 3           | 3           | 1           | 3           | 2           | 1           | 1           |             | 1            | 3            |
| <b>CO 5</b> | 3           | 3           | 3           |             | 3           | 2           | 1           | 1           |             |              | 3            |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         |                       |                    |                                       |
| Understand       | 15                    | 15                 | 30                                    |
| Apply            | 20                    | 20                 | 40                                    |
| Analyse          | 15                    | 15                 | 30                                    |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Radio Wave Propagation:** Ground wave propagation, Plane earth reflection, Space wave and surface wave, Spherical earth propagation, Tropospheric waves, Ionospheric propagation, Effects of earth's magnetic field, Critical frequency, Maximum usable Frequency, Virtual height.

### MODULE 2

**Introduction to Wireless Communication Systems** Generations: 2G, 3G, 4G, 5G. Wireless LAN, Bluetooth and Personal Area networks, Broadband Wireless Access – WiMAX Technology. Wireless Spectrum allocation, Standards.

**Cellular System Design Fundamentals** Frequency Reuse, channel assignment strategies, Handoff strategies, Interference and system capacity, trunking and grade of service, improving coverage and capacity – cell splitting, sectoring, microcells.

### MODULE 3

**Path loss and shadowing:** Free space path loss, Two-Ray model, Shadowing  
**Statistical Multipath Channel Models** Time-varying channel impulse response, Narrowband fading, Wideband fading models, Delay spread and Coherence bandwidth, Doppler spread and Coherence time, Flat fading versus frequency selective fading, Slow fading versus fast fading, Discrete-time model.

**Capacity of Wireless Channels** Review of Capacity in AWGN, Capacity of flat fading channel – Ergodic capacity, Capacity with Outage, Capacity with CSI-R. (Derivations of capacity formulae are not required; Only expressions, computations and significance required.)

### MODULE 4

**Digital Signaling for Flat fading Channels:** Analysis of Average Error Probability and Outage probability of BPSK in flat-fading channels.

**Multi-carrier Modulation:** Data transmission using multicarrier modulation for frequency-selective fading channels. Overlapping subchannels, Mitigation of Subcarrier Fading, Discrete Implementation of multicarrier – OFDM. Cyclic prefix, Peak-to average-power-ratio.

### MODULE 5

**Diversity:** Receiver diversity – selection combining, maximal ratio combining. Transmitter diversity – Alamouti scheme for 2x2 MIMO. **Equalization:** Equalization – Linear and non-linear equalization, Zero forcing, MMSE equalizers. LMS algorithm. Adaptive Equal-

ization. **Multiuser Systems:** Uplink and Downlink, Multiple Access, Frequency-Division Multiple Access (FDMA), Time-Division Multiple Access (TDMA), Code-Division Multiple Access (CDMA), Orthogonal Frequency-Division Multiple Access (OFDMA).

**Text Books**

1. Andrea Goldsmith, Wireless Communications, Cambridge University Press, 2005
2. Theodore S. Rappaport, Wireless communication: Principles and Practice, 2/e, Pearson Education, 1990
3. Aditya Jagannatham, Principles of Modern Wireless Communication Systems, Mc Graw Hill, 2017.
4. Robert Collin, Antennas and Radiowave Propagation, McGraw Hill, 2016.
5. David Tse and Pramod Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005
6. Jochen Schiller, Mobile Communications, Pearson, 2008
7. Andreas F Molish , Wireless Communications, 2nd Edition , Wiley India Publications, 2013
8. W. C. Y. Lee, Mobile Cellular Telecommunication, McGraw Hill
9. Gordon L. Stuber, Principles of Mobile Communication , Springer, 2017
10. Rahim Thafazoli, Technologies for the wireless Future, Vol.2, Wiley and sons, 2004
11. Edward C Jordan and Keith G Balmain, Electromagnetic Wave and Radiating System, Pearson

**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                               | <b>No of Lecture/Tutorial Hours</b> |
|-----------|----------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                                            | <b>7</b>                            |
| 1.1       | Ground wave propagation, Plane earth reflection, Space wave and surface wave.                                              | 2                                   |
| 1.2       | Spherical earth propagation, Tropospheric waves, Ionospheric propagation.                                                  | 2                                   |
| 1.3       | Effects of earth's magnetic field, Critical frequency, Maximum usable Frequency, Virtual height.                           | 3                                   |
|           | <b>Module 2</b>                                                                                                            | <b>8</b>                            |
| 2.1       | Generations: 2G, 3G, 4G, 5G                                                                                                | 2                                   |
| 2.2       | Wireless LAN, Bluetooth and Personal Area networks, Broadband Wireless Access – WiMAX Technology.                          | 1                                   |
| 2.3       | Wireless Spectrum allocation, Standards.                                                                                   | 1                                   |
| 2.4       | Cellular concept, Frequency Reuse, channel assignment strategies,                                                          | 2                                   |
| 2.5       | Interference and system capacity, trunking and grade off service.                                                          | 1                                   |
| 2.6       | improving coverage and capacity – cell splitting, sectoring, microcells.                                                   | 1                                   |
|           | <b>Module 3</b>                                                                                                            | <b>7</b>                            |
| 3.1       | Free space path loss, Two-Ray model, Shadowing                                                                             | 1                                   |
| 3.2       | Time-varying channel impulse response, Narrowband fading                                                                   | 2                                   |
| 3.3       | Wideband fading models – Delay spread and Coherence bandwidth, Doppler spread and Coherence time                           | 1                                   |
| 3.4       | Flat fading versus frequency selective fading, Slow fading versus fast fading, Discrete-time model.                        | 1                                   |
| 3.5       | Review of Capacity in AWGN, Capacity of flat fading channel – Ergodic capacity, Capacity with Outage, Capacity with CSI-R. | 2                                   |
|           | <b>Module 4</b>                                                                                                            | <b>7</b>                            |
| 4.1       | Average Probability of error and outage probability.                                                                       | 1                                   |
| 4.2       | Performance evaluation of BPSK in flat fading channels.                                                                    | 2                                   |
| 4.3       | Multi carrier modulation in frequency-selective channel.                                                                   | 1                                   |
| 4.4       | OFDM – DFT/IDFT, Cyclic Prefix.                                                                                            | 2                                   |
| 4.5       | PAPR.                                                                                                                      | 1                                   |
|           | <b>Module 5</b>                                                                                                            | <b>8</b>                            |
| 5.1       | Receiver Diversity – Selection combining, Maximal ratio combining.                                                         | 2                                   |
| 5.2       | Transmit Diversity – Alamouti for 2x2 MIMO.                                                                                | 1                                   |



|     |                                                                 |                 |
|-----|-----------------------------------------------------------------|-----------------|
| 5.3 | Equalization – linear and nonlinear, ZF and MMSE, LMS, Adaptive | 3               |
| 5.4 | Multiple access – FDMA, TDMA, CDMA, OFDMA.                      | 2               |
|     | <b>Total Hours</b>                                              | <b>37 Hours</b> |

### CO ASSESSMENT QUESTIONS

**Course Outcome 1 (CO 1): Calculate system parameters such antenna height, range, maximum usable frequency in different modes of radio wave propagation. (K3)**

1. Derive expression for critical frequency, maximum usable frequency and skip distance (assuming flat earth's surface) for sky wave propagation.
2. A communication system is to be established at a frequency of 50MHz with a transmitter power 1.2kW. The field strength of the directive antenna is 3 times that of a half wave antenna,  $h_t = 50m$ ,  $h_r = 5m$ . A field strength of  $80\mu V/m$  is required to give satisfactory reception. Find the range of the system.

**Course Outcome 2 (CO 2): Summarize the basics of cellular system and cellular design fundamentals. (K2).**

1. List certain challenges in the design of a cellular wireless communication system.
2. A total of 33MHz of bandwidth is allocated to an FDD cellular system which uses two 25kHz simplex channels to provide full-duplex voice and control channels. Compute the number of channels available per cell if the system uses 7-cell reuse.
3. Describe methods to improve coverage and capacity of a cellular system.

**Course Outcome 3 (CO 3): Describe the wireless channel models and discuss capacity of wireless channels. (K2)**

1. Compare and contrast flat-fading and frequency-selective fading channels.
2. How are Doppler spread and coherence time related? What is their significance?
3. Consider a Rayleigh fading channel with average received power of 25dBm. Compute the probability that the received power is below 10dBm.
4. Differentiate between ergodic capacity and capacity with outage.



**Course Outcome 4 (CO 4):Analyze the performance of the modulation techniques for flatfading channels and multicarrier modulation. (K4)**

1. Under Rayleigh flat-fading, derive an expression for the required average SNR to ensure that outage probability does not below  $P_{out}$  .
2. How can subcarrier fading be mitigated?
3. Why is cyclic prefix required in OFDM?

**Course Outcome 5 (CO 5):Illustrate how receiver performance can be enhanced by various diversity techniques. (K3)**

1. Design a rising-edge detector using an FSM in Verilog. Implement the FSM with a Mealy or Moore output model and provide the necessary testbench to validate its functionality. Explain the design and simulation results.
2. Explain receiver diversity technique of maximal ratio combining technique.
3. Describe Alamouti scheme for 2x2 MIMO.
4. Find the outage probability of BPSK modulation at  $P_b = 10^{-3}$  for a Rayleigh fading channel with SC diversity for  $M = 1$  (no diversity)  $M = 2$ . Assume equal branch SNRs of 15 dB.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24EC3T09**

**Course Name: WIRELESS COMMUNICATION**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Distinguish between critical frequency and maximum usable frequency.
2. Define virtual height in antennas.
3. Give important features of 5G system.
4. Discuss different handoff strategies.
5. Explain the notion of delay spread and coherence bandwidth.
6. Give the expression for capacity of flat fading AWGN channel with CSIR. Describe how it is obtained assuming AWGN capacity.
7. Define outage probability.
8. What is the purpose of using cyclic prefix in an OFDM system?
9. Consider a channel with impulse response  $h(t) = \exp(-t/T)u(t)$ . Find tap coefficients of a two-tap zero-forcing equalizer for this channel.
10. Why do we say that maximal ratio combining achieves full diversity?

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Derive an expression for the LOS distance in km when the antenna heights above ground are  $h_t$  and  $h_r$  respectively for the transmitter and receiver antennas. (7)  
b) A receiving antenna is located at 80km from the transmitting antenna. The height of the transmitting antenna is 100m. What is the required height of the receiving antenna? (7)
12. a) An HF radio communication is to be established between two points on the earth's surface. The points are at a distance of 2600km. The height of the ionosphere layer is 200km and critical frequency is 4MHz. Find maximum usable frequency. (7)  
b) Derive expression for critical frequency, maximum usable frequency and skip distance (assuming flat earth's surface) for sky wave propagation. (7)

**Module II**

13. a) How are co-channel signal-to-interference ratio, cluster size and system capacity are related to one another in a cellular system ? Explain with necessary equations. (7)  
b) Explain the architecture of wireless LAN (WLAN). (7)
14. a) List three differences between 2G and 3G systems. (3)  
b) total of 33MHz of bandwidth is allocated to an FDD cellular system which uses two 25kHz simplex channels to provide full-duplex voice and control channels. Compute the number of channels available per cell if the system uses 7-cell reuse. (3)  
c) What is cell splitting? How does it improve system performance? (8)

**Module III**

15. a) Explain the effect of multipath propagation using 2-ray model. (7)  
b) Assuming narrow band fading model, derive statistical characterization of in-phase and quadrature components of a received signal when an unmodulated carrier is transmitted.. (7)
16. a) Derive time-varying impulse response of multipath wireless channel. (7)  
b) Consider a flat-fading channel with iid channel gains  $g[i]$  which can take on values  $g_1=0.05$  with probability  $p_1=0.1$ ,  $g_2=0.5$  with probability  $p_2=0.5$ , and  $g_3=1$  with probability  $p_3=0.4$ . The transmit power is 10mW, noise spectral density  $N_0 = 10^{-9}W/Hz$ , and channel bandwidth is 30kHz. Assume instantaneous CSI-R, but transmitter does not have CSI. Compute the capacity of the channel. (7)

**Module IV**

17. a) Derive expression for average probability of error in BPSK under Rayleigh flat-fading when symbol duration is roughly equal to channel coherence time. (7)  
b) What is Peak-to-Average Power-Ratio (PAPR) in OFDM system? How can it be reduced ? (7)
18. a) Determine the average SNR per bit of BPSK modulation in Rayleigh slow-fading channel such that 95% of the times, average probability of bit error is less than  $10^{-4}$ . (5)  
b) Explain multi-carrier modulation in OFDM.. (9)

**Module V**

19. a) Explain Least-Mean-Square algorithm for equalization. (9)  
b) Compute the average probability of bit error of BPSK under maximal-ratio combining two-branch diversity with iid Rayleigh fading. Average SNR on each branch is 10dB. (5)
20. a) Describe Alamouti scheme for 2x2 MIMO. (7)  
b) Describe how multiple-access works on uplink and downlink in CDMA. (7)

| B24EC3P21 | DATA<br>STRUCTURES | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|--------------------|---|---|---|---|--------|-------------------------|
|           |                    | 2 | 1 | 0 | 4 | 3      | 2024                    |

**Preamble**

This course is designed to develop a comprehensive understanding of various data structures, their organization, and associated operations. It enables learners to analyze and select appropriate data structures and algorithms for solving computational problems efficiently. This course will explore the abstract concepts of data organization and manipulation through structures such as arrays, stacks, queues, linked lists, trees, heaps, and graphs. The course emphasizes the practical application of these structures in designing efficient solutions for real-world problems in diverse domains of computer science.

By the end of the course, learners will be capable of designing, implementing, and evaluating data structures to optimize program performance and resource utilization.

**Prerequisites**

B24ES1T01A : PROBLEM SOLVING AND PROGRAMMING TECHNIQUES(A)

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                                                                                                       |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Analyze algorithm efficiency using time and space complexity, interpret asymptotic notations, and evaluate the performance of simple algorithms. [Understand, Analyse, Evaluate]                                                                      |
| <b>CO 2</b> | Understand arrays, stacks, and various types of queues for effective data organization, evaluate arithmetic expressions using stack operations, and apply appropriate searching algorithms to retrieve data efficiently. [Understand, Apply Evaluate] |
| <b>CO 3</b> | Apply dynamic memory allocation techniques and implement various linked list structures to manage data efficiently, and analyze different memory allocation schemes. [Apply, Analyse]                                                                 |
| <b>CO 4</b> | Apply tree and graph data structures for organizing and processing data efficiently, and analyze traversal techniques to solve computational problems. [Apply, Analyse]                                                                               |
| <b>CO 5</b> | Implement and analyze different sorting and hashing techniques to efficiently organize, search, and retrieve data. [Apply, Analyse]                                                                                                                   |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 3    | 2    | 2    | 2    |      |      |      |      |       | 1     |
| CO 2 | 3    | 3    | 3    | 2    | 3    |      |      |      |      |       | 1     |
| CO 3 | 3    | 3    | 3    | 2    | 2    |      |      |      |      |       | 1     |
| CO 4 | 3    | 2    | 2    | 2    | 3    |      |      |      |      |       | 1     |
| CO 5 | 2    | 3    | 2    | 3    | 2    |      |      |      |      |       | 1     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 10                    | 10              | 10                                 |
| Understand       | 20                    | 20              | 20                                 |
| Apply            | 30                    | 30              | 30                                 |
| Analyse          | 30                    | 30              | 30                                 |
| Evaluate         | 10                    | 10              | 10                                 |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.



Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.



## SYLLABUS

### MODULE 1

**Basic Concepts of Data Structures:** System Life Cycle, Algorithms, Performance Analysis, Space Complexity, Time Complexity, Asymptotic Notation, Complexity Calculation of Simple Algorithms.

### MODULE 2

**Arrays and Searching** Polynomial representation using Arrays, Sparse matrix, Stacks, Queues-Circular Queues, Priority Queues, Double Ended Queues, Evaluation of Expressions Linear Search and Binary Search.

### MODULE 3

**Linked List and Memory Management:** Self Referential Structures, Dynamic Memory Allocation, Singly Linked List-Operations on Linked List. Doubly Linked List, Circular Linked List, Stacks and Queues using Linked List, Polynomial representation using Linked List Memory allocation and de-allocation-First-fit, Best-fit and Worst-fit allocation schemes

### MODULE 4

**Trees and Graphs:** Trees, Binary Trees-Tree Operations, Binary Tree Representation, Tree Traversals, Binary Search Trees- Binary Search Tree Operations Graphs, Representation of Graphs, Depth First Search and Breadth First Search on Graphs, Applications of Graphs.

### MODULE 5

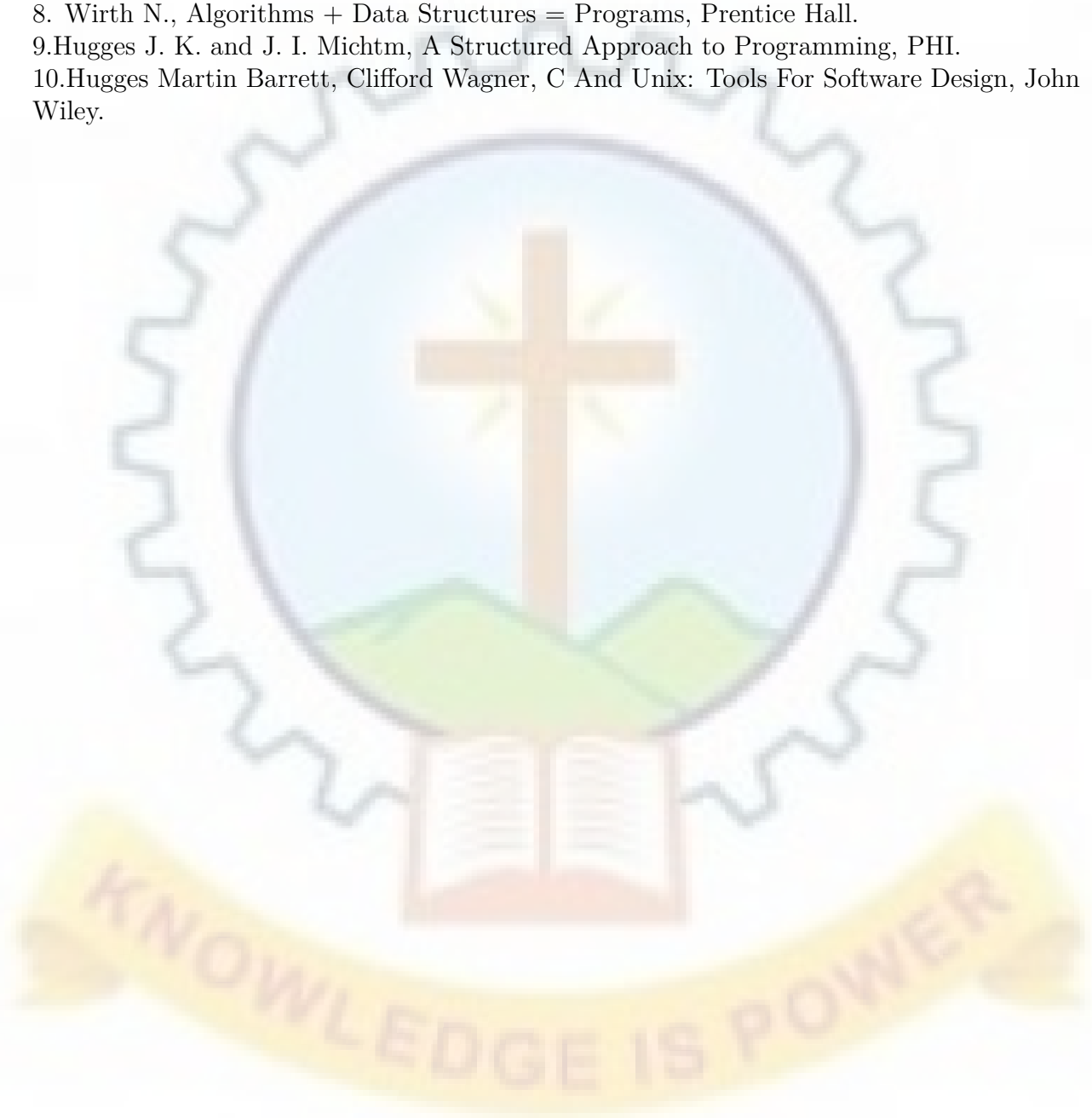
**Sorting and Hashing:** Sorting Techniques – Selection Sort, Insertion Sort, Quick Sort, Merge Sort and Heap Sort Hashing- Hashing Techniques, Collision Resolution, Overflow handling, Hashing functions – Mid square, Division, Folding, Digit Analysis.

### Text Books

1. Ellis Horowitz, Sartaj Sahni and Susan Anderson-Freed, Universities Press, Fundamentals of Data Structures in C
2. Samanta D., Classic Data Structures, Prentice Hall India.
3. Richard F. Gilberg, Behrouz A. Forouzan, Data Structures: A Pseudocode Approach

with C, 2/e, Cengage Learning.f

4. Aho A. V., J. E. Hopcroft and J. D. Ullman, Data Structures and Algorithms, Pearson Publication.
5. Tremblay J. P. and P. G. Sorenson, Introduction to Data Structures with Applications, Tata McGraw Hill.
6. Peter Brass, Advanced Data Structures, Cambridge University Press.
7. Lipschuts S., Theory and Problems of Data Structures, Schaum's Series.
8. Wirth N., Algorithms + Data Structures = Programs, Prentice Hall.
9. Hugges J. K. and J. I. Michtm, A Structured Approach to Programming, PHI.
10. Hugges Martin Barrett, Clifford Wagner, C And Unix: Tools For Software Design, John Wiley.



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                    | No of Lecture/Tutorial Hours |
|-----|--------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1 :Basic Concepts of Data Structures</b>                       | <b>5</b>                     |
| 1.1 | System Life Cycle,                                                       | 1                            |
| 1.2 | Algorithms , Performance Analysis                                        | 1                            |
| 1.3 | Space Complexity, Time Complexity                                        | 1                            |
| 1.4 | Asymptotic Notation (Big O Notation)                                     | 1                            |
| 1.5 | Complexity Calculation of Simple Algorithms                              | 1                            |
|     | <b>Module 2 :Arrays and Searching</b>                                    | <b>7</b>                     |
| 2.1 | Polynomial representation using Arrays                                   | 1                            |
| 2.2 | Sparse matrix                                                            | 1                            |
| 2.3 | Stacks                                                                   | 1                            |
| 2.4 | Queues, Circular Queues                                                  | 1                            |
| 2.5 | Priority Queues,Double Ended Queues                                      | 1                            |
| 2.6 | Conversion and Evaluation of Expressions                                 | 1                            |
| 2.7 | Linear Search and Binary Search                                          | 1                            |
|     | <b>Module 3 : Linked List and Memory Management</b>                      | <b>8</b>                     |
| 3.1 | Self Referential Structures                                              | 1                            |
| 3.2 | Dynamic Memory Allocation                                                | 1                            |
| 3.3 | Singly Linked List-Operations on Linked List                             | 1                            |
| 3.4 | Doubly Linked List,Circular Linked List                                  | 1                            |
| 3.5 | Stacks using Linked List,Queues using Linked List                        | 1                            |
| 3.6 | Polynomial representation using Linked List                              | 1                            |
| 3.7 | Memory de-allocation,Memory allocation-First-fit                         | 1                            |
| 3.8 | Best-fit and Worst-fit allocation schemes                                | 1                            |
|     | <b>Module 4 :Trees and Graphs</b>                                        | <b>8</b>                     |
| 4.1 | Trees, Binary Trees                                                      | 1                            |
| 4.2 | Tree Operations, Binary Tree Representation                              | 1                            |
| 4.3 | Tree Traversals                                                          | 1                            |
| 4.4 | Binary Search Trees                                                      | 1                            |
| 4.5 | Binary Search Tree Operations                                            | 1                            |
| 4.6 | Graphs, Representation of Graphs                                         | 1                            |
| 4.7 | Depth First Search and Breadth First Search on Graphs                    | 1                            |
| 4.8 | Applications of Graphs                                                   | 1                            |
|     | <b>Module 5 : Sorting and Hashing</b>                                    | <b>8</b>                     |
| 5.1 | Sorting Techniques – Selection Sort                                      | 1                            |
| 5.2 | Insertion Sort,Quick Sort                                                | 1                            |
| 5.3 | Merge Sort,Heap Sort                                                     | 1                            |
| 5.4 | Code development of an FSMD, Debouncing circuit based on RT methodology. | 1                            |
| 5.5 | Collision Resolution.                                                    | 1                            |
| 5.6 | Overflow handling                                                        | 1                            |

|     |                                                     |                 |
|-----|-----------------------------------------------------|-----------------|
| 5.7 | Hashing functions – Mid square and Division methods | 1               |
| 5.8 | Folding and Digit Analysis methods                  | 1               |
|     | <b>Total Hours</b>                                  | <b>36 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Write an algorithm to find the largest element in an array of n numbers. a) Calculate the time complexity and space complexity of your algorithm.
2. Design an algorithm for matrix multiplication of two matrices. a) Calculate its time complexity and space complexity.

#### Course Outcome 2 (CO 2):

1. Write an algorithm to perform linear search and binary search on an array of integers. Compare their time complexities.
2. Given a sparse matrix, write an algorithm to represent it efficiently using arrays and to find its transpose.

#### Course Outcome 3 (CO 3):

1. Create a Binary search Tree with node representing the following sequence 14, 15, 4, 18, 9, 16, 20, 17, 3, 7, 5, 2 and perform inorder, preorder and postorder traversals on the above tree and print the output.
2. Explain the concept of memory management and discuss the first-fit, best-fit, and worst-fit allocation schemes.

#### Course Outcome 4 (CO 4):

1. Construct a binary search tree (BST) using the sequence: 14, 15, 4, 18, 9, 16, 20, 17, 3, 7, 5, 2. Perform inorder, preorder, and postorder traversals.
2. Write algorithms for Depth First Search (DFS) and Breadth First Search (BFS) on graphs.

#### Course Outcome 5 (CO 5):

1. The size of a hash table is 7. Insert keys 89, 18, 49, 58, 25 using linear probing and show the resulting table.
2. Sort the numbers 38, 8, 0, 28, 45, -12, 89, 66, 42 using Quick Sort. Show intermediate steps.





MODEL QUESTION PAPER

QP CODE:

Pages: 5

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027

**Course Code: B24EC3P21**

**Course Name: DATA STRUCTURES**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define time complexity and space complexity. Why are they important in algorithm design?
2. Calculate the frequency count of the statement  $x = x + 1$ ; in the following code:  
$$\text{for } (i = 0; i < n; i++) \text{ for } (j = 0; j < n; j++) \quad x = x + 1;$$
3. Write an algorithm to insert an element into a specific position of an array.
4. Differentiate between linear search and binary search.
5. Write an algorithm to evaluate a postfix expression using a stack implemented with arrays.
6. What are self-referential structures? Give an example in C.
7. Write an algorithm to delete a node from a singly linked list at a given position.
8. Define a Binary Search Tree (BST). List any two important properties.
9. What are collision resolution techniques in hashing? Give any two examples.
10. Differentiate between Quick Sort and Merge Sort with respect to performance.

## PART B

(Answer one full question from each module. Each question carries 14 Marks)

### Module 1

11. a) Explain the different phases of the System Life Cycle with a neat diagram. (8)  
b) Write an algorithm for matrix multiplication and calculate its time and space complexity. (6)

OR

12. a) Explain various asymptotic notations with suitable examples. (8)  
b) Compare the complexities  $O(n \log n)$  and  $O(n^2)$  and comment on their relative performance. (6)

### Module 2

13. a) Write algorithms for linear search and binary search, and compare their time complexities. (10)  
b) Explain the representation of a sparse matrix using arrays with its advantages. (4)

OR

14. a) Explain how arrays can be used to represent polynomials. Write an algorithm to add two polynomials using arrays. (10)  
b) Write short notes on circular queue implementation using arrays. (4)

### Module 3

15. a) Write algorithms to insert and delete nodes from a doubly linked list with an example. (10)  
b) Explain first-fit, best-fit and worst-fit memory allocation schemes. (4)

OR

16. a) Explain how linked lists can be used to represent and add two bivariate polynomials. Write the algorithm. (10)  
b) Compare stack implementation using arrays and linked lists. (4)

### Module 4

17. a) Construct a Binary Search Tree (BST) using the sequence:  
14, 15, 4, 18, 9, 16, 20, 17, 3, 7, 5, 2.  
Perform inorder, preorder, and postorder traversals. (10)  
b) Discuss any two applications of graphs. (4)

**OR**

18. **a)** Write algorithms for Depth First Search (DFS) and Breadth First Search (BFS) with examples. (10)  
**b)** Explain adjacency matrix and adjacency list representations of graphs. (4)

**Module 5**

19. **a)** Write algorithms for Quick Sort and Merge Sort. Compare their best- and worst-case performances. (10)  
**b)** Perform Quick Sort on the sequence: 38, 8, 0, 28, 45, -12, 89, 66, 42. Show all intermediate steps. (4)

**OR**

20. **a)** Explain different hashing techniques and collision resolution methods with examples. (10)  
**b)** Apply the hash function  $h(x) = x \bmod 7$  on the data: 2341, 4234, 2839, 430, 22, 397, 3920 using linear probing and show the resulting hash table. (4)

| B24EC3P22 | MECHATRONICS | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|--------------|---|---|---|---|--------|----------------------|
|           |              | 2 | 1 | 0 | 4 | 3      | 2024                 |

### Preamble

This course introduces the fundamentals of Mechatronic systems integrating mechanical, electrical, and control engineering concepts. It emphasizes sensors, actuators, system modeling, MEMS, and robotics applications in modern automation.

### Prerequisites

NIL

### Course Outcomes

After the completion of the course, the student will be able to:

|      |                                                                                                                                                                                                  |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Explain the basic elements, design process, and sensors used in Mechatronic systems, including their classification and characteristics.[Understand, Remember]                                   |
| CO 2 | Describe the working principles and applications of various actuators such as hydraulic, pneumatic, and electrical drives, and design simple circuits using standard symbols.[Understand, Apply] |
| CO 3 | Develop mathematical models for mechanical and electrical systems and design simple ladder logic programs using PLCs for automation tasks.[Apply,Remember]                                       |
| CO 4 | Explain the fabrication processes and working principles of MEMS devices such as pressure sensors, accelerometers, and gyroscopes. [Understand]                                                  |
| CO 5 | Apply mechatronic concepts in robotic systems, including sensor and actuator selection, robotic vision, and image processing techniques.[Understand, Analyze]                                    |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    | 2    | 1    | 2    | 1    |      | 1    |      |       | 2     |
| CO 2 | 3    | 2    | 3    | 2    | 2    | 1    | 1    |      |      |       | 2     |
| CO 3 | 3    | 3    | 3    | 3    | 3    |      |      |      | 1    | 1     | 2     |
| CO 4 | 3    | 2    | 2    | 2    | 2    |      |      |      |      |       | 2     |
| CO 5 | 3    | 3    | 3    | 3    | 3    |      | 1    | 1    | 1    | 2     | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 70                    | 70                 | 70                                    |
| Apply            | 10                    | 10                 | 10                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Introduction to Mechatronics Systems:** Basic elements of Mechatronics systems, Design process of system. Sensors- classification, static and dynamic characteristics- Potentiometer, LVDT, Capacitive Sensors. Strain Guages, Eddy current sensors, Hall effect sensors, Velocity sensors, Temperature sensors, Encoders, Resolver, Piezoelectric sensor, Acoustic emission sensor, Vibration sensors.

### MODULE 2

**Actuators :** Hydraulic and Pneumatic actuators - Directional control valves, pressure control valves, process control valves. Rotary actuators. Development of simple hydraulic and pneumatic circuits using standard Symbols. Electrical drives: DC, AC, brush-less, servo and stepper motors.

### MODULE 3

**System modeling :** Mathematical models and basic building blocks of general mechanical and electrical systems. Programmable Logic Controllers (PLC) –Basic structure, input/output processing. Timers, Internal Relays, Counters and Shift registers. Development of simple ladder programs for specific purposes.

### MODULE 4

**Micro Electro Mechanical Systems (MEMS) :** Fabrication: Deposition, Photolithography, Micromachining methods for MEMS -Surface and Bulk, Deep Reactive Ion Etching (DRIE) and LIGA processes. Principle, fabrication and working of MEMS based pressure sensor, accelerometer and gyroscope

### MODULE 5

**Mechatronics in Robotics:** - Choice of Sensors and Actuators. Robotic vision system – Image acquisition: Vidicon, charge coupled device (CCD). Image processing techniques: histogram processing: sliding, stretching, equalization and thresholding. Case studies of Mechatronics systems: Simple weighing machine, pick and place robot.

### Text Books

1. Bolton W., Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Person Education Limited, New Delhi, 2007
2. Ramachandran K. P., G. K. Vijayaraghavan, M. S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Wiley India Pvt. Ltd., New Delhi, 2008.



3. Saeed B. Niku, Introduction to Robotics: Analysis, Systems, Applications, Person Education, Inc., New Delhi, 2006.
4. David G. Aldatore, Michael B. Hstand, Introduction to Mechatronics and Measurement Systems, McGraw-Hill Inc., USA, 2003.
5. Gordon M. Mair, Industrial Robotics, Prentice Hall International, UK, 1998
6. Vijay K. Varadan, K. J. Vinoy, S. Gopalakrishnan, Smart Material Systems and MEMS: Design and Development Methodologies, John Wiley & Sons Ltd., England, 2006.

## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                      | No of Lecture/Tutorial Hours |
|-----|--------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                            | <b>7</b>                     |
| 1.1 | Basic elements of Mechatronics systems, Design process of system.                          | 1                            |
| 1.2 | Sensors- classification, static and dynamic characteristics                                | 1                            |
| 1.3 | Sensors- Potentiometer, LVDT, Capacitive Sensors                                           | 2                            |
| 1.4 | Strain Gauges, Eddy current sensors, Hall effect sensors                                   | 1                            |
| 1.5 | Velocity sensors, Temperature sensors, Encoders, Resolver                                  | 2                            |
| 1.6 | Piezoelectric sensor, Acoustic emission sensor, Vibration sensors.                         | 1                            |
|     | <b>Module 2</b>                                                                            | <b>6</b>                     |
| 2.1 | Hydraulic and Pneumatic systems                                                            | 1                            |
| 2.2 | Directional control valves, pressure control valves                                        | 1                            |
| 2.3 | Process control valves, Rotary actuators                                                   | 1                            |
| 2.4 | Development of simple hydraulic and pneumatic circuits using standard Symbols              | 2                            |
| 2.5 | Electrical drives: DC, AC, brush-less, servo and stepper motors                            | 1                            |
|     | <b>Module 3</b>                                                                            | <b>7</b>                     |
| 3.1 | Mathematical models and basic building blocks of general mechanical and electrical systems | 2                            |
| 3.2 | Programmable Logic Controllers (PLC) –Basic structure, input/ output processing            | 1                            |
| 3.3 | Logic functions, Timers, Internal Relays                                                   | 1                            |
| 3.4 | Counters and Shift registers.                                                              | 1                            |
| 3.5 | Development of simple ladder programs for specific purposes.                               | 2                            |
|     | <b>Module 4</b>                                                                            | <b>6</b>                     |
| 4.1 | MEMS-Fabrication: Thin Film Deposition- PVD                                                | 1                            |
| 4.2 | Photolithography                                                                           | 1                            |
| 4.3 | Micromachining methods for MEMS -Surface and Bulk                                          | 1                            |

|     |                                                                                                        |                 |
|-----|--------------------------------------------------------------------------------------------------------|-----------------|
| 4.4 | Deep Reactive Ion Etching (DRIE) and LIGA processes                                                    | 1               |
| 4.5 | Principle, fabrication and working of MEMS based pressure sensor                                       | 1               |
| 4.5 | Accelerometer and gyroscope                                                                            | 1               |
|     | <b>Module 5</b>                                                                                        | <b>6</b>        |
| 5.1 | Choice of Sensors and Actuators.                                                                       | 1               |
| 5.2 | Robotic vision system – Image acquisition: Vidicon, charge coupled device (CCD)                        | 1               |
| 5.3 | Image processing techniques: histogram processing: sliding, stretching, equalization and thresholding. | 2               |
| 5.4 | Case studies of Mechatronics systems: Simple weighing machine, pick and place robot.                   | 2               |
|     | <b>Total Hours</b>                                                                                     | <b>36 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the basic elements of a Mechatronic system with a neat block diagram.
2. Describe the static and dynamic characteristics of sensors with suitable examples.
3. Explain the working principle and applications of an LVDT and a capacitive sensor

#### Course Outcome 2 (CO 2):

1. Compare hydraulic and pneumatic actuators with examples of typical applications.
2. Draw and explain a simple pneumatic circuit using standard symbols for controlling a single-acting cylinder.
3. Describe the construction and operation of a stepper motor and list its Mechatronic applications.

#### Course Outcome 3 (CO 3):

1. Derive the mathematical model for a translational mechanical system consisting of a mass, damper, and spring.
2. Develop a ladder logic diagram for an automatic motor start–stop control using a PLC.

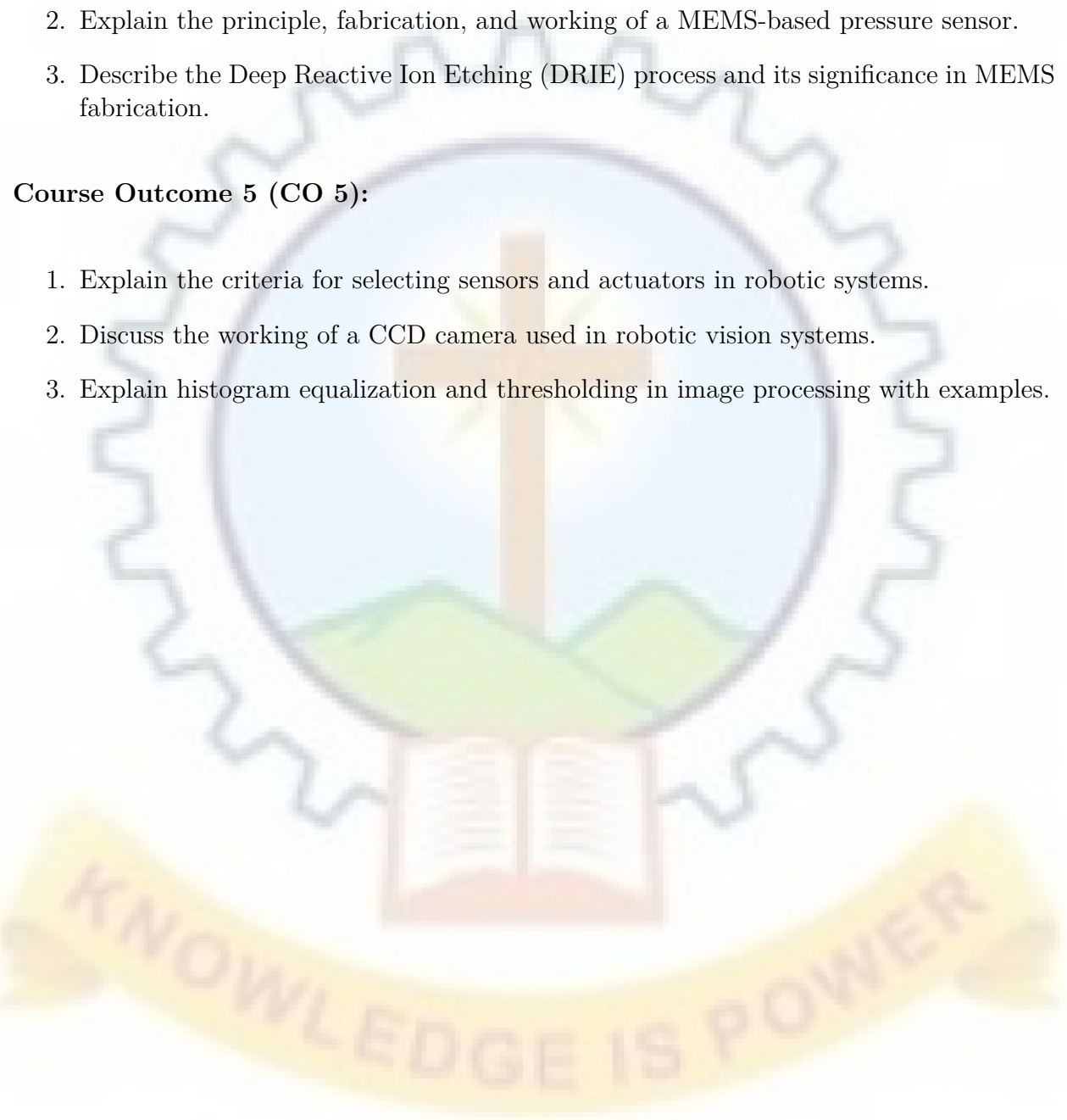
3. Explain the role of timers and counters in PLC programming with suitable examples.

**Course Outcome 4 (CO 4):**

1. Compare surface micromachining and bulk micromachining techniques used in MEMS fabrication.
2. Explain the principle, fabrication, and working of a MEMS-based pressure sensor.
3. Describe the Deep Reactive Ion Etching (DRIE) process and its significance in MEMS fabrication.

**Course Outcome 5 (CO 5):**

1. Explain the criteria for selecting sensors and actuators in robotic systems.
2. Discuss the working of a CCD camera used in robotic vision systems.
3. Explain histogram equalization and thresholding in image processing with examples.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24EC3P22**

**Course Name: MECHATRONICS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define Mechatronics and list the basic elements of a Mechatronic system.
2. Explain the role of sensors and actuators in a Mechatronic system.
3. Differentiate between static and dynamic characteristics of sensors.
4. Explain the working principle of a strain gauge and state its applications.
5. What are Hall effect sensors? Mention one industrial use.
6. Describe the function of directional control valves in hydraulic systems.
7. Compare servo motors and stepper motors used in Mechatronic applications.
8. What are the advantages of using PLCs in automation systems?
9. Define MEMS and mention any two micromachining techniques used in MEMS fabrication.
10. What are the main components of a robotic vision system?

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain the key elements and design process of a Mechatronic system with a neat block diagram. (7)  
b) Classify sensors and explain the working principle of LVDT in detail. (7)
12. a) Define and discuss the static and dynamic characteristics of sensors with examples. (7)  
b) Explain the working of Hall effect sensor and eddy current sensor. (7)

**Module II**

13. a) Describe the construction and working of hydraulic and pneumatic actuators with neat sketches. (7)  
b) Explain the operation of pressure and process control valves. (7)
14. a) Compare DC, AC, brushless, servo, and stepper motors based on control, speed, and torque characteristics (7)  
b) Design a simple pneumatic circuit using standard symbols for a pick-and-place mechanism. (7)

**Module III**

15. a) Derive the mathematical model for a simple mechanical translational system. (7)  
b) Explain the basic structure and input/output processing of a PLC. (7)
16. a) Write a ladder logic diagram for automatic ON/OFF control of a motor using start and stop pushbuttons. (7)  
b) Discuss the working of timers and counters in PLC-based automation. (7)

**Module IV**

17. a) Explain the photolithography process used in integrated circuit fabrication. (7)  
b) Describe the principle, fabrication, and working of a MEMS-based accelerometer. (7)
18. a) Explain the Deep Reactive Ion Etching (DRIE) process in MEMS fabrication. (7)  
b) Discuss the working of gyroscope sensors with applications. (7)

**Module V**

19. a) Explain the choice of sensors and actuators in robotic systems. (7)  
b) Describe the operation and control of a pick-and-place robot system. (7)
20. a) Explain the Mechatronic components and working of a simple weighing machine. (7)  
b) Discuss image acquisition using CCD cameras and describe histogram equalization in robotic vision. (7)

| <b>B24EC3P23</b> | <b>MODERN COMMUNICATION SYSTEMS</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF INTRODUCTION</b> |
|------------------|-------------------------------------|----------|----------|----------|----------|---------------|-----------------------------|
|                  |                                     | 2        | 1        | 0        | 4        |               |                             |

**Preamble**

This course aims to impart knowledge on the basics of modern communication systems and the break through wireless technologies.

**Prerequisites**

B24EC3T03 : Analog And Digital Communication.

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                      |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Describe cellular system structure, frequency reuse, handoff, channel assignment, and interference reduction techniques [Understand] |
| <b>CO 2</b> | Discuss the different wireless communication standards for short range communication. [Apply]                                        |
| <b>CO 3</b> | Explain the significance and architecture of software defined radio and cognitive radio. [Apply]                                     |
| <b>CO 4</b> | Explain the IoT architecture and various connectivity technologies used in IoT Systems. [Apply]                                      |
| <b>CO 5</b> | Understand the various communication standards for connected autonomous vehicles. [Understand]                                       |

**Mapping of Course Outcomes With Program Outcomes**

|             | <b>PO 1</b> | <b>PO 2</b> | <b>PO 3</b> | <b>PO 4</b> | <b>PO 5</b> | <b>PO 6</b> | <b>PO 7</b> | <b>PO 8</b> | <b>PO 9</b> | <b>PO 10</b> | <b>PO 11</b> |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|
| <b>CO 1</b> | 3           | 3           | 3           |             | 2           |             |             |             |             |              |              |
| <b>CO 2</b> | 3           | 3           | 3           |             |             | 3           |             |             |             |              | 1            |
| <b>CO 3</b> | 3           | 3           | 3           |             |             | 3           |             |             |             |              |              |
| <b>CO 4</b> | 3           | 3           | 3           |             |             | 3           |             |             |             |              | 1            |
| <b>CO 5</b> | 3           | 3           | 3           |             | 2           |             |             |             |             |              |              |

**Assessment Pattern**



| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Introduction to cellular systems:** Basic Cellular System- Cellular communication infrastructure: Cells- Clusters- Cell Splitting- Frequency reuse concept and reuse distance calculation- Cellular system components- Operations of cellular systems- Handoff / Handover- Channel assignment- Fixed and dynamic- Cellular interferences Co-Channel and adjacent channel and sectorization.

### MODULE 2

**Introduction to modern cellular standards:** GSM and CDMA- GPRS- UMTS LTE-Introduction- 4G (LTE-A) Mobile network architecture, technology, LTE-frequency band, LTE Frame structure, operating mode, LTE channel types; 5G Evolution, Extension of 4G- D2D standardization to 5G.

**Introduction to 5G:** AI/ML to improve channels and other functionalities of networks; Role of AI/ML in resource/channel allocation

### MODULE 3

**Software radio :** Software radio concepts, Operating frequency bands, Transmitter and Receiver specifications of SDR, Architecture of SDR, Introduction to cognitive radio, significance of cognitive radio and spectrum subleasing, spectrum sharing in cognitive radio, Cognitive radio network architecture. Applications, Implementation of cognitive radio, Cognitive process.

### MODULE 4

**IoT-Introduction:** Definition of IoT- Characteristics-Physical and logical design-IoT, Connectivity technologies, IoT- Communication Technologies, IoT architectures and protocols, IoT levels of deployment template.

**Case Studies and Future Trends:** Agricultural IoT, Vehicular IoT, Healthcare IoT.

### MODULE 5

**Vehicular Communication Introduction to Intelligent Transport system:** Evolution, Vehicular Networks and ITS, Vehicular Communication Standards.

**Wireless Access for Vehicular Environments (WAVE) and Its Migration Towards IEEE 802.11p:** DSRC, IEEE 1609, LED-Enabled Visible Light Communications (IEEE TG 802.15.7), 4G/5G Device to Device (D2D), 6G Cellular network and automated vehicles, Operational Scenario- Collision Avoidance. Automated Route Guidance for Emergency Response Vehicles, 6G for Vehicle-to-Everything (V2X) Communications :Enabling Technologies, Challenges, and Opportunities.

**Text Books**

1. T.S. Rappaport, “Wireless Communication, Principles and Practice, Pearson Education”, Second Edition, 2010.
2. Andrea Goldsmith, “Wireless Communications”, Cambridge University Press, 2005.
3. Afif Osseiran, Jose F Monserrat, Patrick Marsch, “5G Mobile and Wireless Communications Technology”, Cambridge University Press, 2016.
4. Sudip Misra, Anandarup Mukherjee Arijit Roy. “Introduction to IoT”.Cambridge University Press. 2021.
5. George J. Dimitrakopoulos. “Current Technologies in Vehicular Communication”, Springer International Publishing, 2017.
6. Noor-A-Rahim, Zilong Liu, Haeyoung Lee, Mohammad Omar Khyam, Jianhua He, Dirk Pesch. “6G for Vehicle-to-Everything (V2X) Communications: Enabling Technologies, Challenges, and Opportunities
7. Walter Tuttlebee, “SDR Enabling Technologies”, John Wiley
8. Huseyin Arslan, “Cognitive Radio, SDR and Adaptive Wireless System” Springer, 2007

**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                               | <b>No of Lecture/Tutorial Hours</b> |
|-----------|------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                            | <b>6</b>                            |
| 1.1       | Introduction to cellular systems-Basic Cellular System-Cellular communication infrastructure.              | 1                                   |
| 1.2       | Cells-Clusters-Cell Splitting Frequency reuse concept and reuse distance calculation.                      | 1                                   |
| 1.3       | Cellular system components.                                                                                | 1                                   |
| 1.4       | Operations of cellular systems.                                                                            | 1                                   |
| 1.5       | Handoff/Handover-Channel assignment-Fixed and dynamic.                                                     | 1                                   |
| 1.6       | Cellular interferences: Co-Channel and adjacent channel and sectorization.                                 | 1                                   |
|           | <b>Module 2</b>                                                                                            | <b>7</b>                            |
| 2.1       | Introduction to modern cellular standards-GSM and CDMA-GPRS-UMTS-LTE.                                      | 1                                   |
| 2.2       | Introduction to 4G(LTE-A) Mobile network architecture,technology.                                          | 1                                   |
| 2.3       | LTE-frequency band, LTE Frame structure,operating mode.                                                    | 1                                   |
| 2.4       | LTE channel types;5 G Evolution.Extension of 4 G-D2D standardization to 5 G.                               | 2                                   |
| 2.5       | Introduction to 5 G AI/ML to improve channels and other functionalities of networks.                       | 1                                   |
| 2.6       | Role of AI/ML in resource/channel allocation.                                                              | 1                                   |
|           | <b>Module 3</b>                                                                                            | <b>7</b>                            |
| 3.1       | Software radio concepts,Operating frequency bands.                                                         | 1                                   |
| 3.2       | Transmitter and Receiver specifications of SDR.                                                            | 1                                   |
| 3.3       | Architecture of SDR.                                                                                       | 2                                   |
| 3.4       | Introduction to cognitive radio, significance of cognitive radio and spectrum subleasing,spectrum sharing. | 1                                   |
| 3.5       | Cognitive radio network architecture.                                                                      | 1                                   |
| 3.6       | Applications,Implementation of cognitive radio,Cognitive process.                                          | 1                                   |
|           | <b>Module 4</b>                                                                                            | <b>7</b>                            |
| 4.1       | Definition of IoT-Characteristics of IoT.                                                                  | 1                                   |
| 4.2       | Physical and logical design-IoT.                                                                           | 2                                   |
| 4.3       | IoT connectivity technologies.                                                                             | 1                                   |
| 4.4       | IoT architectures and protocols.                                                                           | 2                                   |
| 4.5       | Case Studies and Future Trends Agricultural IoT,Vehicular IoT,Health care IoT.                             | 1                                   |
|           | <b>Module 5</b>                                                                                            | <b>8</b>                            |

|                    |                                                                                                             |                 |
|--------------------|-------------------------------------------------------------------------------------------------------------|-----------------|
| 5.1                | Vehicular Communication Introduction to Intelligent Transport system–Evolution, Vehicular Networks and ITS. | 1               |
| 5.2                | Vehicular Communication Standards-WAVE,DSRC, IEEE 1609.                                                     | 2               |
| 5.3                | LED-Enabled Visible Light Communications (IEEE TG 802.15.7).                                                | 1               |
| 5.4                | 4G/5G Device to Device (D2D) 6G cellular networks and automated vehicles.                                   | 1               |
| 5.5                | Operational Scenario–Collision Avoidance.                                                                   | 1               |
| 5.6                | Automated Route Guidance for Emergency Response Vehicles.                                                   | 1               |
| 5.7                | 6G for Vehicle-to-Everything (V2X) Communications,Enabling Technologies,Challenges,and Opportunities.       | 1               |
| <b>Total Hours</b> |                                                                                                             | <b>35 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain basic cellular structure and components.
2. Describe frequency reuse, cell splitting, and hand off operations.
3. Explain the different channel assignment methods and interference reduction techniques.

#### Course Outcome 2 (CO 2):

1. Compare GSM, CDMA, UMTS, LTE, and 5G systems.
2. Describe LTE architecture, frame structure, and channels.
3. Explain AI/ML roles in 5G network optimization and resource allocation.

#### Course Outcome 3 (CO 3):

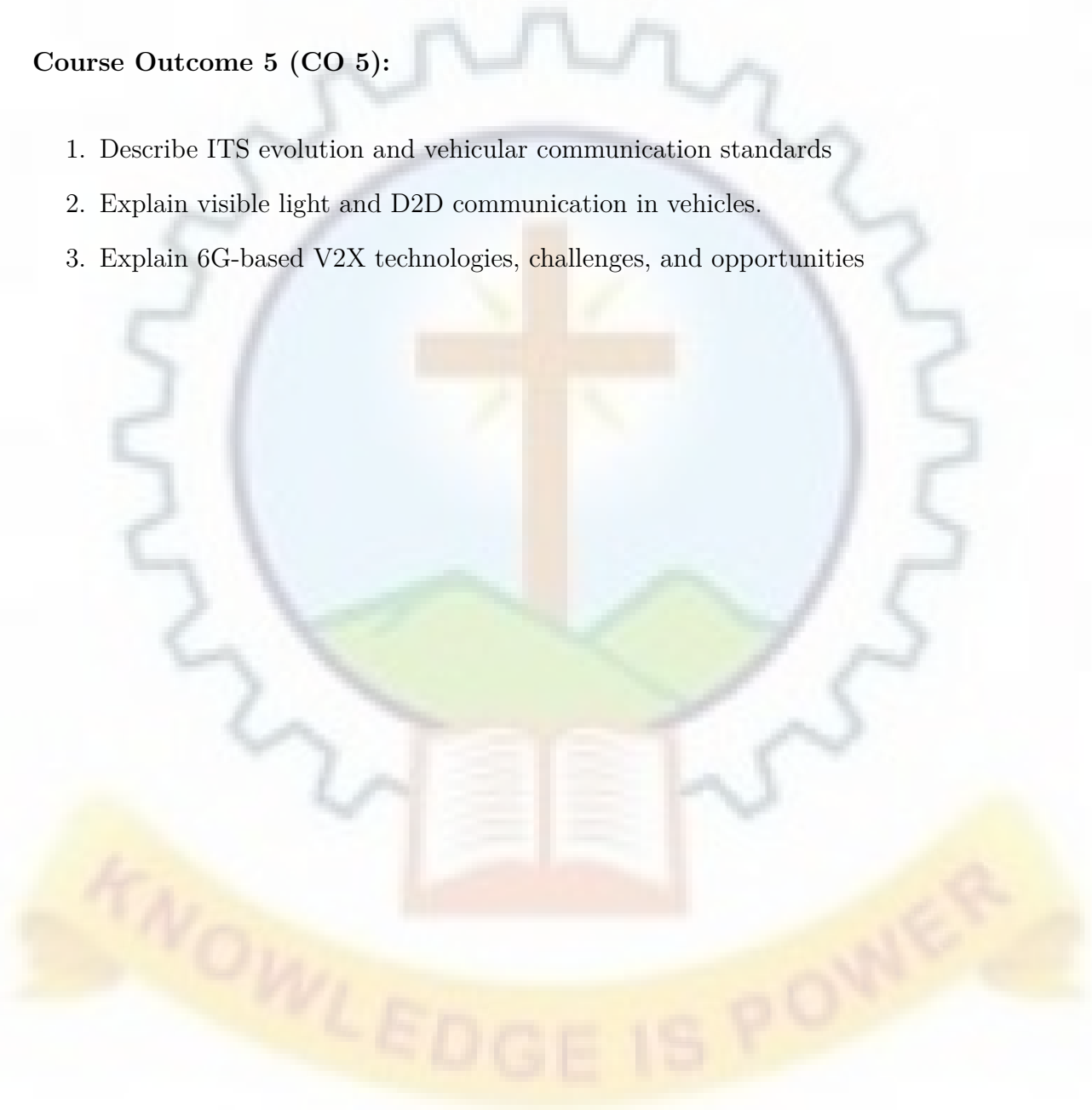
1. Explain basic cellular structure and components.
2. Describe frequency reuse, cell splitting, and hand off operations.
3. Explain the different channel assignment methods and interference reduction techniques.

**Course Outcome 4 (CO 4):**

1. Define IoT and its physical and logical design.
2. Explain IoT connectivity technologies and architectures.
3. Explain IoT protocols for smart communication.

**Course Outcome 5 (CO 5):**

1. Describe ITS evolution and vehicular communication standards
2. Explain visible light and D2D communication in vehicles.
3. Explain 6G-based V2X technologies, challenges, and opportunities





**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 3**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24EC3P23**

**Course Name: MODERN COMMUNICATION SYSTEMS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define cell and cluster in a cellular system.
2. What are co-channel and adjacent channel interferences?
3. Compare GSM and CDMA based on technology and access methods.
4. Explain the role of AI/ML in improving resource or channel allocation in 5G networks.
5. Define Software Defined Radio (SDR).
6. What is cognitive radio? Mention its significance in spectrum utilization.
7. Summarize the characteristics of IoT?
8. Write a short note on IoT connectivity technologies .
9. What is Intelligent Transport System (ITS)?
10. What is Vehicle-to-Everything (V2X) communication? Mention any two enabling technologies for 6G V2X.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain in detail the frequency reuse concept in cellular systems. Derive the reuse distance formula and discuss its importance. (7)  
b) What is a handoff (handover)? Explain different types of handoff and the criteria for handoff initiation. (7)
12. a) Explain cell splitting and how it improves system capacity. Illustrate with a neat diagram. (7)  
b) What are the different channel assignment strategies used in cellular systems. Explain in details. (7)

**Module II**

13. a) Explain the architecture and working of GSM in detail. Mention its key features and advantages. (7)  
b) Describe the LTE mobile network architecture and explain the LTE frame structure with a suitable diagram. (7)
14. a) Compare GSM, CDMA, and LTE in terms of multiple access techniques, frequency bands, and data rates. (7)  
b) Explain the evolution from 4G (LTE-A) to 5G highlighting the major technological advancements. (7)

**Module III**

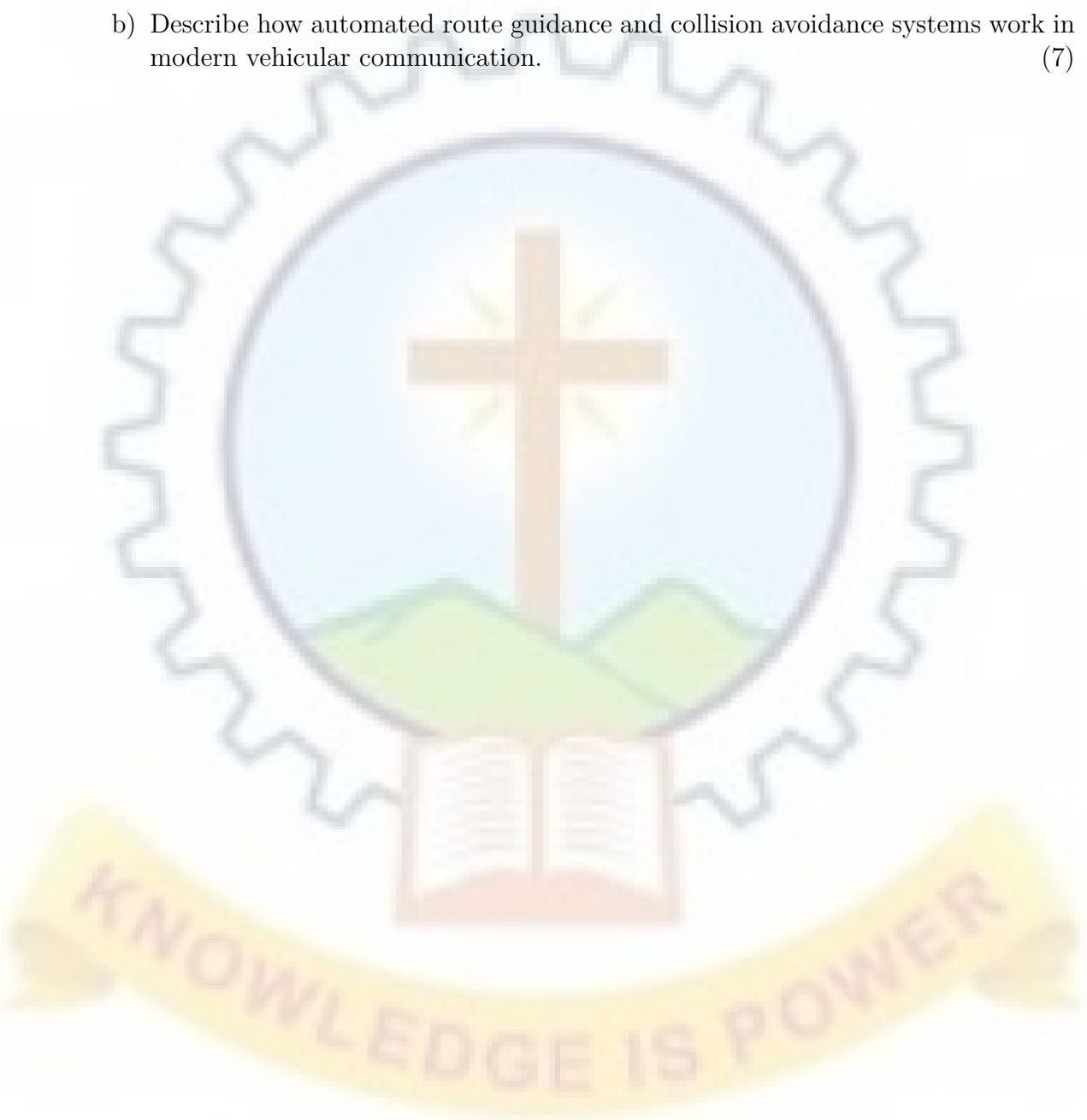
15. a) Compare traditional radio and software defined radio in terms of flexibility, re-configurability, and implementation. (7)  
b) Explain the Cognitive Radio Network Architecture with neat block diagrams and discuss its functional blocks. (7)
16. a) Explain the Zero IF architecture of Software Defined Radio (SDR) and discuss the specifications of its transmitter and receiver. (7)  
b) Discuss the applications and implementation challenges of cognitive radio networks. (7)

**Module IV**

17. a) Discuss various IoT architectures and communication protocols used in IoT systems. (7)  
b) Explain level 6 IoT with applications. (7)
18. a) Discuss different IoT connectivity technologies such as Bluetooth, ZigBee, Wi-Fi, and LoRa.. (7)  
b) Explain future trends in IoT and how IoT is transforming industries like health care and agriculture . (7)

**Module V**

19. a) Explain the WAVE (Wireless Access for Vehicular Environments) standard and its evolution to IEEE 802.11p and DSRC. (7)  
b) Discuss the concept of 6G-enabled Vehicle-to-Everything (V2X) communications and highlight its challenges and opportunities. (7)
20. a) Explain Device-to-Device (D2D) communication and its role in vehicular networks. (7)  
b) Describe how automated route guidance and collision avoidance systems work in modern vehicular communication. (7)



| B24EC3P24 | INTERNET OF THINGS | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|--------------------|---|---|---|---|--------|----------------------|
|           |                    | 2 | 1 | 0 | 4 |        |                      |

### Preamble

This course introduces the fundamentals of the Internet of Things (IoT), covering architecture, hardware platforms, sensors, communication protocols, and cloud integration, while providing both theoretical understanding and practical exposure to real-world IoT applications

### Prerequisites

B24EC2T02 : COMPUTER ARCHITECTURE AND MICROCONTROLLERS

### Course Outcomes

After the completion of the course, the student will be able to:

|             |                                                                                                |
|-------------|------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Explain the fundamental architecture and functional blocks of IoT systems. [Understand, Apply] |
| <b>CO 2</b> | Interface sensors, actuators, and communication modules with IoT boards. [Understand, Apply]   |
| <b>CO 3</b> | Implement data acquisition and connectivity using MQTT/HTTP protocols. [Understand, Apply]     |
| <b>CO 4</b> | Design small-scale IoT prototypes using cloud integration and APIs. [Understand, Apply]        |
| <b>CO 5</b> | Evaluate performance and constraints of embedded IoT implementations. [Understand, Apply]      |

### Mapping of Course Outcomes With Program Outcomes

|            | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO1</b> | 3    | 2    | 2    |      | 2    | 1    | 1    |      | 2    | 2     | 2     |
| <b>CO2</b> | 2    | 3    | 2    | 2    | 3    | 1    |      | 2    | 2    | 1     | 2     |
| <b>CO3</b> | 2    | 3    | 2    | 2    | 2    | 1    | 1    | 1    | 1    | 2     | 2     |
| <b>CO4</b> | 3    | 2    | 3    | 1    | 2    |      |      |      | 2    | 2     | 1     |
| <b>CO5</b> | 2    | 2    | 3    | 2    | 2    | 1    |      |      | 2    | 2     | 1     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**IoT Fundamentals and Ecosystem:** Definition, characteristics, and evolution of IoT– Physical vs logical design; IoT functional blocks– IoT ecosystem: sensors, actuators, gateway, cloud, analytics, user interface– Challenges: interoperability, scalability, latency, power management, and security– Overview of major application domains: smart home, agriculture, health, industry.

### MODULE 2

**IoT Hardware Platforms and Interfacing:** Overview of Arduino, ESP32, and Raspberry Pi architectures– I/O organization: GPIO, ADC/DAC, timers, PWM– Interfacing sensors and actuators (temperature, motion, light, soil-moisture, relays, motors)– Circuit design basics: wiring, pull-ups, shields, level shifting– Serial communication and debugging (UART, I2C, SPI)– Case study: sensor-to-cloud data acquisition setup.

### MODULE 3

**IoT Networking and Communication Protocols:** IoT communication stack overview– Wired and wireless interfaces: Wi-Fi, Bluetooth, Zigbee, LoRa, GPS– Application protocols: HTTP, MQTT, CoAP– IPv6 and 6LoW PAN basics for constrained networks– Socket programming and RESTful API concepts– Demonstration: MQTT-based data transfer between device and broker.

### MODULE 4

**IoT Data Management and Cloud Integration :** IoT data flow architecture (device → gateway → cloud → dashboard)– IoT cloud service models: IaaS, PaaS, DaaS, Cloud platforms: ThingSpeak, Firebase, AWS IoT, Blynk (overview and APIs)– Data formats: JSON, CSV; publishing and subscribing data– Cloud dashboard setup and visualization– Basic data analytics and control feedback– Edge vs cloud computing: performance trade-offs.

### MODULE 5

**Embedded Programming and IoT Applications:** Real-time and embedded constraints: memory, timing, multitasking - RTOS concepts: tasks, semaphores, scheduling (overview)– Project design cycle: problem definition, hardware selection, coding, testing, cloud link - Ex-



ample applications: smart home automation, environmental monitoring, smart agriculture, water management, health and wearable systems - Mini-project discussion and evaluation guidelines.

### **Text Books**

1. Arshdeep Bahga & Vijay Madisetti, Internet of Things: A Hands-On Approach, Universities Press, 2014
2. Adrian McEwen & Hakim Cassimally, Designing the Internet of Things, Wiley, 2013
3. Sudip Misra, Anandarup Mukherjee & Arijit Roy. Introduction to IoT. Cambridge University Press. 2021
4. Olivier Hersent, David Boswarthick, & Omar Elloumi, The Internet of Things: Key Applications and Protocols, Wiley, 2012.
5. Hanes, T., Salgueiro, G., Grossetete, P., Barton, R., & Henry, J., IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, Cisco Press, 2017.
6. Daniel Minoli, Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications, Wiley, 2013.
7. Rajkumar Buyya & Amir Vahid Dastjerdi, Internet of Things: Principles and Paradigms, Elsevier, 2016.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                                        | <b>No of Lecture/Tutorial Hours</b> |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                                                     | <b>7</b>                            |
| 1.1       | Definition, characteristics, and evolution of IoT                                                                                   | 1                                   |
| 1.2       | Physical vs logical design                                                                                                          | 2                                   |
| 1.3       | IoT functional blocks.                                                                                                              | 1                                   |
| 1.4       | IoT ecosystem: sensors, actuators, gateway, cloud, analytics, user inter face                                                       | 2                                   |
| 1.5       | Challenges: interoperability, scalability, latency, power management, and security                                                  | 1                                   |
|           | <b>Module 2</b>                                                                                                                     | <b>8</b>                            |
| 2.1       | Overview of Arduino, ESP32, and Raspberry Pi architectures.                                                                         | 1                                   |
| 2.2       | I/O organization: GPIO, ADC/DAC, timers,                                                                                            | 2                                   |
| 2.3       | PWM– Interfacing sensors and actuators (temperature, motion, light, soil-moisture, relays, motors).                                 | 2                                   |
| 2.4       | Circuit design basics: wiring, pull-ups, shields, level shifting                                                                    | 2                                   |
| 2.5       | Serial communication and debugging (UART, I2C, SPI).                                                                                | 2                                   |
| 2.6       | Case study:sensor-to-cloud data acquisition setup.                                                                                  | 1                                   |
|           | <b>Module 3</b>                                                                                                                     | <b>6</b>                            |
| 3.1       | IoT communication stack                                                                                                             | 1                                   |
| 3.2       | Wired and wireless interfaces: Wi-Fi, Bluetooth, Zigbee, LoRa, GPS                                                                  | 1                                   |
| 3.3       | Application protocols: HTTP, MQTT, CoAP– IPv6 and 6LoW PAN basics for constrained networks                                          | 2                                   |
| 3.4       | Socket programming and RESTful API concepts - Demonstration                                                                         | 1                                   |
| 3.5       | MQTT-based data transfer between device and broker                                                                                  | 1                                   |
|           | <b>Module 4</b>                                                                                                                     | <b>8</b>                            |
| 4.1       | : IoT data flow architecture                                                                                                        | 2                                   |
| 4.2       | IoT cloud service models: IaaS,PaaS,DaaS.                                                                                           | 1                                   |
| 4.3       | Cloud platforms: ThingSpeak, Firebase, AWS IoT, Blynk                                                                               | 1                                   |
| 4.4       | Data formats: JSON, CSV; publishing and subscribing data.                                                                           | 2                                   |
| 4.5       | Cloud dashboard setup and visualization- Basic data analytics and control feedback– Edge vs cloud computing: performance tradeoffs. | 2                                   |
|           | <b>Module 5</b>                                                                                                                     | <b>6</b>                            |
| 5.1       | Real-time and embedded constraints: memory, timing, multitasking.                                                                   | 1                                   |
| 5.2       | RTOS concepts: tasks, semaphores, scheduling.                                                                                       | 1                                   |

|     |                                                                                                                                          |                 |
|-----|------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 5.3 | Project design cycle: problem definition, hardware selection, coding, testing, cloud link                                                | 2               |
| 5.4 | Example applications: smart home automation, environmental monitoring, smart agriculture, water management, health and wearable systems. | 2               |
|     | <b>Total Hours</b>                                                                                                                       | <b>35 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the physical and logical design of an IoT system with suitable examples.
2. Discuss the key challenges in IoT deployment such as interoperability, scalability, and security.

#### Course Outcome 2 (CO 2):

1. Compare the architectures and features of Arduino, ESP32, and Raspberry Pi.
2. Explain the interfacing of a temperature sensor and relay module with an ESP32 board using GPIO.

#### Course Outcome 3 (CO 3):

1. Describe the architecture and working of the MQTT protocol in IoT communication.
2. Explain the role of IPv6 and 6LoWPAN in IoT networking for constrained devices.

#### Course Outcome 4 (CO 4):

1. Illustrate the data flow in a cloud-connected IoT system from device to dashboard.
2. Discuss the setup and use of ThingSpeak or Blynk platform for IoT data visualization.

#### Course Outcome 5 (CO 5):

1. Explain the significance of RTOS concepts like tasks and semaphores in IoT applications.
2. Outline the project design cycle for developing a smart home automation IoT prototype.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24EC3P24**

**Course Name: INTERNET OF THINGS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. List and explain any three characteristics of the Internet of Things (IoT).
2. What are the major functional blocks of an IoT system? Briefly describe each.
3. Compare Arduino and ESP32 in terms of features and applications.
4. Write short notes on GPIO and PWM functionalities in IoT hardware boards.
5. Differentiate between MQTT and HTTP protocols used in IoT.
6. What is the significance of Zigbee and LoRa in IoT communication?
7. Define JSON and explain its role in IoT data communication.
8. What are the advantages of using cloud platforms like ThingSpeak or Firebase in IoT?
9. Mention any three real-time constraints in embedded IoT systems.
10. Write short notes on any one IoT application in smart agriculture or healthcare.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain the physical and logical design of an IoT system . (7)  
b) Discuss the key challenges in IoT deployment such as interoperability, scalability, and security. (7)
12. a) Illustrate the main design principles of an IoT architecture. (7)  
b) Discuss the challenges and characteristics of IoT systems in modern industrial applications. (7)

**Module II**

13. a) Describe the architecture of ESP32 and explain its advantages over Arduino. (7)  
b) With a neat diagram, explain how sensors and actuators are interfaced with an IoT board. (7)
14. a) Differentiate between Arduino and Raspberry Pi with respect to processing and interfacing. (3)  
b) Write short notes on ADC and DAC in IoT hardware platforms. (3)

**Module III**

15. a) State the purpose of the MQTT protocol in IoT communication. (3)  
b) What are the advantages of using LoRa for IoT networks? (3)
16. a) Describe the IoT communication stack and explain the roles of each layer in data transmission. (7)  
b) Explain the functioning of CoAP and HTTP protocols in IoT. Compare their efficiency in constrained environments. (7)

**Module IV**

17. With a neat block diagram, explain the complete IoT data flow architecture from devices to cloud and dashboard. Discuss each stage in detail. (14)
18. Explain in detail the setup and operation of an IoT cloud platform (ThingSpeak, Firebase, or AWS IoT) for data acquisition, storage, and visualization. (14)

**Module V**

19. Explain the real-time and embedded system constraints in IoT such as memory, timing, and multitasking. Discuss how these constraints affect IoT performance. (14)
20. Describe the architecture and working of a Real-Time Operating System (RTOS). Explain how tasks, semaphores, and scheduling are managed in IoT applications. (14)

| B24EC3P25 | ARM SYSTEM ARCHITECTURE | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|-------------------------|---|---|---|---|--------|----------------------|
|           |                         | 2 | 1 | 0 | 4 | 3      | 2024                 |

### Preamble

This course introduces embedded system fundamentals and ARM Cortex-M microcontroller architecture with emphasis on STM32. It covers processor features, memory organization, exception handling, and peripheral interfacing. Through hands-on programming with real-time applications, students gain practical skills in developing and debugging embedded and IoT-based systems.

### Prerequisites

B24EC2T02 : COMPUTER ARCHITECTURE AND MICROCONTROLLERS

B24ES1T01A : PROBLEM SOLVING AND PROGRAMMING TECHNIQUES

### Course Outcomes

After the completion of the course, the student will be able to:

|             |                                                                                                                                                       |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the fundamentals of embedded computing and ARM processor families, especially Cortex-M architecture. [Understand]                          |
| <b>CO 2</b> | Understand the instruction set, registers, operating modes, exception handling, and memory organization in ARM Cortex-M microcontrollers [Understand] |
| <b>CO 3</b> | Develop embedded C and basic assembly programs for ARM processors and demonstrate memory-mapped programming. [Understand, Apply]                      |
| <b>CO 4</b> | Interface on-chip peripherals such as GPIO, timers, ADC, and UART for real-time applications. [Apply]                                                 |
| <b>CO 5</b> | Apply real-time embedded system concepts including interrupts, watchdog timers, and low-power modes in practical designs. [Apply, Analyse]            |

### Mapping of Course Outcomes With Program Outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 2    |      |      | 1    |      | 1    |      |      |       | 1     |
| <b>CO 2</b> | 3    | 2    | 1    | 1    | 1    |      |      |      |      |       | 1     |
| <b>CO 3</b> | 3    |      | 3    | 2    | 3    |      |      |      | 2    | 1     | 2     |
| <b>CO 4</b> | 3    | 2    | 3    | 2    | 3    | 1    | 1    | 1    | 2    | 1     | 2     |
| <b>CO 5</b> | 2    | 2    | 3    | 3    | 3    | 2    | 1    | 1    | 2    | 2     | 3     |



### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 30                    | 30                 | 30                                    |
| Apply            | 50                    | 50                 | 50                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Introduction to Embedded and ARM Systems:** Embedded computers – Characteristics and applications; Challenges in embedded computing; Embedded system design process – requirements and specifications; Overview of ARM processor family– ARM7, ARM9, ARM11, and Cortex series. Introduction to ARM architecture and core features; pipelining. Introduction to Cortex M3.

### MODULE 2

**Cortex-M3 Architecture:** Instruction Set Architecture, Load-store design and addressing modes; Register set and Program Status Registers; Processor operating modes, Software interrupts and exception entry/response flow with vector table; Bus structure and peripheral connection; Memory organization; Processor booting and initialization sequence; STM32 development environment; GPIO basics for input/output configuration.

### MODULE 3

**Programming and Memory Basics:** C programming on Cortex-Mx (variables, pointers, structures), Registers and simple assembly instructions, Understanding memory: Flash & SRAM, Using timers: Timer-based LED blinking pattern, Delay generation using Timer.

### MODULE 4

**Peripherals & Communication:** ADC for sensor data, Read temperature sensor using ADC, UART for serial communication, Send sensor data to PC using UART, Basic interfacing with common electronic modules.

### MODULE 5

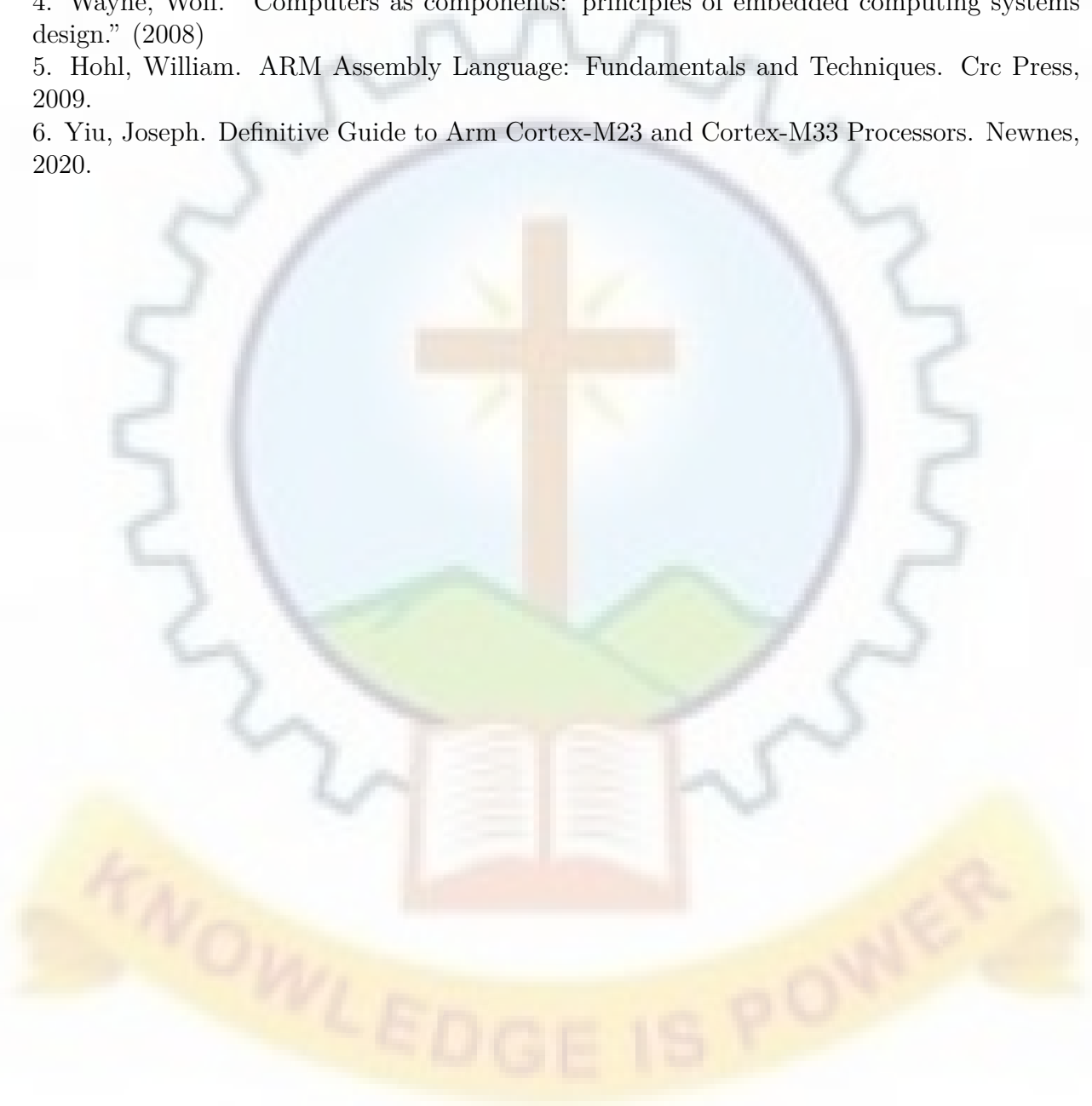
**Real-Time Basics:** Interrupt priorities (NVIC), Watchdog timer, Implement periodic tasks using timer interrupts, Power-saving basics for battery-powered devices, System reset demonstration using watchdog timer, Integrating sensors and display serial output, Simple IoT concept introduction, Debugging and testing techniques

### Text Books

1. Mazidi, Muhammad Ali, et al. ARM assembly language programming & architecture. www. MicroDigitalEd. com, 2016.
2. Furber, Stephen Bo. ARM system-on-chip architecture. pearson Education, 2000.

### **Reference Books**

1. Seal, David, ed. ARM architecture reference manual. Pearson Education, 2001.
2. Vahid, Frank, and Tony D. Givargis. Embedded system design: a unified hardware/software introduction. John Wiley & Sons, 2001.
3. Sloss, ANDREW N., D. W. C. Symes, and C. H. R. I. S. Wright. "Arm embedded systems." ARM System Developer's Guide: Designing and Optimizing System Software (2004): 2-16.
4. Wayne, Wolf. "Computers as components: principles of embedded computing systems design." (2008)
5. Hohl, William. ARM Assembly Language: Fundamentals and Techniques. Crc Press, 2009.
6. Yiu, Joseph. Definitive Guide to Arm Cortex-M23 and Cortex-M33 Processors. Newnes, 2020.



**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                                                                               | No of Lecture/Tutorial Hours |
|-----|---------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                     | <b>9</b>                     |
| 1.1 | Embedded systems: Definition, characteristics & applications                                                        | 2                            |
| 1.2 | Embedded system design process: Requirements & specifications and Challenges in embedded design                     | 2                            |
| 1.3 | ARM processor family overview -ARM7, ARM9, ARM11, Cortex Series                                                     | 2                            |
| 1.4 | ARM processor core features, Pipelining concepts                                                                    | 2                            |
| 1.5 | Introduction to Cortex-M architecture, Cortex-M3 features & tools overview (STM32 basics)                           | 1                            |
|     | <b>Module 2</b>                                                                                                     | <b>9</b>                     |
| 2.1 | Cortex-M3 Instruction Set Architecture (ISA), Load-store design, Addressing modes                                   | 2                            |
| 2.2 | Register set & Program Status Registers (PSR)                                                                       | 2                            |
| 2.3 | Processor operating modes, Software interrupts (SVC), Exception entry/response flow, Vector table                   | 2                            |
| 2.4 | Bus structure (AHB/APB), Peripheral connection, Memory organization (Flash/SRAM/stack)                              | 2                            |
| 2.5 | Processor booting & initialization, STM32 development environment introduction, GPIO basics (I/O config)            | 1                            |
|     | <b>Module 3</b>                                                                                                     | <b>9</b>                     |
| 3.1 | C programming on Cortex-Mx; Variables, data types, pointers (peripheral access), structures for register definition | 2                            |
| 3.2 | Registers and simple assembly instructions (load/store, move, branch)                                               | 2                            |
| 3.3 | Understanding MCU memory: Flash vs SRAM, memory map, stack usage                                                    | 2                            |
| 3.4 | Timer basics: SysTick/General-purpose timer, Timer configuration                                                    | 2                            |
| 3.5 | Timer-based LED blinking pattern, Delay generation using Timer                                                      | 1                            |
|     | <b>Module 4</b>                                                                                                     | <b>9</b>                     |
| 4.1 | ADC basics, ADC architecture in STM32, Channel and resolution concepts                                              | 2                            |
| 4.2 | Reading sensor data using ADC: Sampling rate, conversion steps, temperature sensor interfacing basics               | 2                            |
| 4.3 | UART basics: Serial communication format, baud rate generation, TX/RX register usage                                | 2                            |
| 4.4 | Sending sensor data to PC using UART: Data formatting, polling/interrupt mode concept                               | 2                            |

|     |                                                                                                                   |                 |
|-----|-------------------------------------------------------------------------------------------------------------------|-----------------|
| 4.5 | Basic interfacing with common electronic modules (switch, buzzer, LCD/7-segment overview) and integration concept | 1               |
|     | <b>Module 5</b>                                                                                                   | <b>9</b>        |
| 5.1 | NVIC and Interrupt Priorities — Nested interrupts, vector table usage, priority configuration                     | 2               |
| 5.2 | Timer interrupts for periodic tasks — Scheduling basics, ISR coding structure                                     | 2               |
| 5.3 | Watchdog timer — Purpose, configuration, system reset demonstration                                               | 2               |
| 5.4 | Power-saving basics for battery-powered devices — Sleep modes, clock gating, energy efficiency                    | 2               |
| 5.5 | Integrating sensors; serial display output, Simple IoT concept intro, Debugging & testing techniques              | 1               |
|     | <b>Total Hours</b>                                                                                                | <b>45 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the key characteristics and applications of embedded systems. Describe typical challenges in embedded computing.
2. Explain the ARM processor family evolution (ARM7, ARM9, ARM11, Cortex series). Discuss how RISC design and pipelining enhance the performance of ARM-based embedded systems.

#### Course Outcome 2 (CO 2):

1. Illustrate the Cortex-M3 register organization and different processor modes. Explain exception handling with the role of Software Interrupt (SWI) instructions.
2. Explain the Cortex-M3 load-store architecture and classify its addressing modes with appropriate examples. Write assembly instruction examples demonstrating any four addressing modes supported by the Cortex-M3 instruction set.

#### Course Outcome 3 (CO 3):

1. Write an embedded C program for Cortex-M3 to blink an LED using direct register access. Use pointers and structures to access the GPIO registers. Explain how memory-mapped I/O is implemented in STM32 with reference to the Flash and SRAM memory map.

2. Write a program to configure SysTick to generate a 1-second delay and use it to toggle an LED continuously. Show the delay calculation using the system clock frequency.

**Course Outcome 4 (CO 4):**

1. Write an embedded C program on Cortex-M3 to read temperature sensor data using the ADC and display the measured temperature value on a serial terminal. Explain the ADC configuration steps including channel selection, conversion time, and resolution settings.
2. Write a program to configure UART for serial transmission at a baud rate of 9600 bps and send a custom text message continuously to a PC terminal. Explain how the UART registers (data, control, and status) control the communication process.

**Course Outcome 5 (CO 5):**

1. Write a program to configure the Independent Watchdog Timer (IWDG) and demonstrate a system reset when the watchdog is not refreshed in time. Explain why this mechanism is essential for reliable IoT and industrial applications.
2. Design a periodic ADC-based sensing system using a timer interrupt where the microcontroller enters sleep mode between events to conserve power.



MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, NOVEMBER 2026

**Course Code: B24EC3P25**

**Course Name: ARM SYSTEM ARCHITECTURE**

Max. Marks: 100

Duration: 3 hours

**PART A**

*Answer all questions. Each question carries 3 marks*

1. Define an embedded system. List four typical characteristics of embedded systems.?
2. State major architectural features of ARM Cortex-M processors.?
3. Explain the load-store nature of the Cortex-M3 instruction set?
4. Differentiate between ARM and Thumb-2 instruction sets used in Cortex-M3.?
5. What are the different operating modes in Cortex-M3?
6. What is the purpose of PSR (Program Status Register) in Cortex-M3?
7. Describe the function of GPIO pins in STM32 microcontrollers.?
8. Compare UART, SPI, and I2C communication protocols.?
9. Explain the need for watchdog timer in real-time embedded systems.?
10. Why are Cortex-M processors widely preferred in IoT and battery-powered embedded applications?

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain the design process of an embedded system with a neat block diagram.? (7)  
b) Explain ARM processor family evolution and justify the need for Cortex-M architecture in modern embedded devices.? (7)
12. a) Describe the challenges in embedded computing and suggest possible solutions.? (7)  
b) Explain pipelining in ARM processors with timing diagram? (7)

**Module II**

13. a) Explain ARM processor modes and exception handling mechanism using a diagram? (7)  
b) Describe the exception entry and return flow using vector table and stack frame? (7)
14. a) Classify addressing modes in Cortex-M3 with instruction examples.? (7)  
b) Explain memory organization and booting sequence in STM32? (7)

**Module III**

15. a) Write an ARM assembly program to add two 32-bit numbers and store result in SRAM. Explain the register roles? (7)  
b) Explain the concepts of Flash & SRAM memory usage in embedded C program execution? (7)
16. a) Write a program to toggle LED using direct GPIO register access. Explain memory-mapped I/O in STM32.? (7)  
b) Explain the usage of SysTick timer to generate accurate delays with calculation? (7)

**Module IV**

17. a) Write code to interface a switch and LED using GPIO. Explain software debouncing? (7)  
b) Explain ADC configuration for temperature measurement and conversion formula? (7)
18. a) Describe the steps to configure UART for serial communication with baud rate calculation? (7)

- b) Explain interfacing of ADC and UART to send sensor data to PC terminal? (7)

***Module V***

19. a) Explain NVIC interrupt priority and preemption with a diagram? (7)  
b) Discuss the role of low-power modes in battery-powered IoT applications? (7)
20. a) Explain the operation of Watchdog timer and system reset demonstration.? (7)  
b) With block diagram, describe a timer-based periodic sensing system for IoT data transmission? (7)



| B24EC3G11 | RENEWABLE<br>ENERGY<br>SYSTEMS | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|--------------------------------|---|---|---|---|--------|-------------------------|
|           |                                | 2 | 1 | 0 | 4 | 3      | 2024                    |

**Preamble**

Objective of this course is to inculcate in students an awareness of new and renewable energy sources.

**Prerequisites**

NIL

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                            |
|-------------|--------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Discuss the appropriate energy source depending on the available sources [Understand]      |
| <b>CO 2</b> | Understand the concepts of solar thermal and solar electric systems.[Understand]           |
| <b>CO 3</b> | Describe the operating principles of wind and ocean energy conversion systems [Understand] |
| <b>CO 4</b> | Summarise the features of biomass and small hydro energy resources. [Understand]           |
| <b>CO 5</b> | Describe the concepts of fuel cell and hydro energy resources. [Understand]                |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 2    | 2    | 1    |      | 1    |      |      |      |       | 1     |
| <b>CO 2</b> | 3    | 3    | 3    | 2    |      | 1    |      |      |      |       | 1     |
| <b>CO 3</b> | 3    | 3    | 3    | 2    |      | 1    |      |      |      |       | 1     |
| <b>CO 4</b> | 3    | 2    | 2    | 2    | 2    | 2    |      |      |      |       | 1     |
| <b>CO 5</b> | 2    | 2    | 3    | 3    | 3    | 2    | 2    |      | 1    | 1     | 3     |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 25                    | 25              | 50                                 |
| Understand       | 25                    | 25              | 50                                 |
| Apply            |                       |                 |                                    |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## **SYLLABUS**

### **MODULE 1**

**ENERGY RESOURCES :** Conventional Energy Resources - Availability and their limitations- Non-Conventional Energy Resources – Classification, Advantages, Limitations; Comparison. SOLAR THERMAL SYSTEMS- Principle of Conversion of Solar Radiation into Heat – Solar thermal collectors. SOLAR ELECTRIC SYSTEMS- Solar Thermal Electric Power Generation – Solar Photovoltaic – Solar Cell fundamentals - characteristics, classification, construction. Solar PV Systems – stand-alone and grid connected- Applications

### **MODULE 2**

**ENERGY FROM OCEAN:** Ocean Thermal Energy Conversion (OTEC)- Principle of OTEC system- Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle. Siteselection criteria- Biofouling- Advantages & Limitations of OTEC. TIDAL ENERGY – Principle of Tidal Power- Components of Tidal Power Plant (TPP)- Classification-single basin- double basin types –Limitations -Environmental impacts.

### **MODULE 3**

**WIND ENERGY:** Introduction to wind energy- Basic principles of Wind Energy Conversion Systems (WECS) wind speed measurement-Classification of WECS- types of rotors. wind power equation -Betz limit. Electrical Power Output and Capacity Factor of WEC- SAdvantages and Disadvantages of WECS -site selection criteria.

### **MODULE 4**

**BIOMASS ENERGY:** Introduction to Biomass energy- Biomass fuels-Biomass conversion technologies -Urban waste to Energy Conversion- Biomass Gasification- Biomass to Ethanol Production- Biogas production from waste biomass- factors affecting biogas generation-types of biogas plants – KVIC and Janata model-Biomass program in India

### **MODULE 5**

**SMALL HYDRO POWER:** Classification as micro, mini and small hydro projects - Basic concepts and types of turbines- selection considerations. Emerging Technologies : Fuel Cell- principle of operation –classification- conversion efficiency and losses - applications .Hydrogen energy -hydrogen production -electrolysis - thermo chemical methods -hydrogen storage and utilization.



**Text Books**

1. G. D. Rai, “ Non Conventional Energy Sources”, Khanna Publishers, 2010
2. Rao S. and B. B. Parulekar, Energy Technology, Khanna Publishers, 1999
3. G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications,Narosa Publishers, 2002
4. Sawhney G. S., Non-Conventional Energy Resources, PHI Learning, 2012.
5. Tiwari G. N., Solar Energy- Fundamentals, Design, Modelling and Applications,CRC Press, 2002



**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                                                                   | <b>No of Lecture/Tutorial Hours</b> |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                                                                                | <b>7</b>                            |
| 1.1       | Conventional Energy Resources - Availability and their limitations .                                                                                           | 1                                   |
| 1.2       | Non-Conventional Energy Resources – Classification, Advantages, Limitations; Comparison                                                                        | 1                                   |
| 1.3       | SOLAR THERMAL SYSTEMS- Principle of Conversion of Solar Radiation into Heat – Solar thermal collectors.                                                        | 1                                   |
| 1.4       | SOLAR ELECTRIC SYSTEMS- Solar Thermal Electric Power Generation                                                                                                | 1                                   |
| 1.5       | Solar Photovoltaic – Solar Cell fundamentals - characteristics, classification, construction.Solar PV Systems – stand alone and grid connected- Applications . | 3                                   |
|           | <b>Module 2</b>                                                                                                                                                | <b>7</b>                            |
| 2.1       | Ocean Thermal Energy Conversion (OTEC)- Principle of OTEC system Siteselection criteria- single basin- double basin types –Limitations -                       | 2                                   |
| 2.2       | Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle.                                                                                     | 1                                   |
| 2.2       | Biofouling- Advantages and limitations.                                                                                                                        | 2                                   |
| 2.4       | TIDAL ENERGY – Principle of Tidal Power- Components of Tidal Power Plant (TPP)- Classification                                                                 | 1                                   |
| 2.5       | Environmental impacts                                                                                                                                          | 1                                   |
|           | <b>Module 3</b>                                                                                                                                                | <b>7</b>                            |
| 3.1       | WIND ENERGY- Introduction- Basic principles of Wind Energy Conversion Systems (WECS)                                                                           | 1                                   |
| 3.2       | Wind Energy Conversion Systems (WECS) wind speed measurement                                                                                                   | 2                                   |
| 3.3       | Classification of WECS- types of rotors. wind power equation -Betz limit.                                                                                      | 2                                   |
| 3.4       | Electrical Power Output and Capacity Factor of WECS and its advantages and disadvantages and site selection criteria                                           | 2                                   |
|           | <b>Module 4</b>                                                                                                                                                | <b>7</b>                            |
| 4.1       | Introduction- Biomass fuels-Biomass conversion technologies                                                                                                    | 1                                   |
| 4.2       | Urban waste to energy conversion -Biomass gasification-factors affecting biogas generation                                                                     | 2                                   |
| 4.3       | Types of biogas plants – KVIC and Janata model-Biomass program in India                                                                                        | 2                                   |
| 4.4       | Biomass program in India                                                                                                                                       | 2                                   |
|           | <b>Module 5</b>                                                                                                                                                | <b>8</b>                            |

|     |                                                                                                           |                 |
|-----|-----------------------------------------------------------------------------------------------------------|-----------------|
| 5.1 | Small hydro projects and classifications .Basic concepts and types of turbines- selection considerations. | 2               |
| 5.2 | Fuel Cell-principle of operation –classification- conversion efficiency and losses - applications         | 2               |
| 5.3 | Hydrogen energy -hydrogen production -electrolysis                                                        | 2               |
| 5.4 | Thermo chemical methods -hydrogen storage and utilization.                                                | 2               |
|     | <b>Total Hours</b>                                                                                        | <b>36 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Discuss primary and secondary energy sources. Describe future of non-conventional energy resources in India
2. Principle and operation of Solar its characteristics, classification and construction.

#### Course Outcome 2 (CO 2):

1. What are the main types of OTEC plants. Describe the working of open cycle OTEC power plant with its neat sketch.
2. Explain the various methods of tidal power generation. What are the limitations of each method.

#### Course Outcome 3 (CO 3):

1. Derive the expression for power in the wind turbine. Classify tidal power plants and brief explain any two of them.
2. Discuss Wind Energy Conversion Systems (WECS) wind speed measurement

#### Course Outcome 4 (CO 4):

1. Describe different types of biomass conversion technologies..
2. Discuss types of biogas plants and Biomass program in India

#### Course Outcome 5 (CO 5):

1. With the help of neat diagram explain the power generation from a small hydro power station.
2. Explain the hydrogen production system and hydrogen storage and utilization



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24EC3G11**

**Course Name: RENEWABLE ENERGY SYSTEMS**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Explain about the role of non-conventional energy sources on the basis of current energy demands of the world.
2. Explain the principle of solar energy conversion into heat energy.
3. List out any four environmental impacts of OTEC systems
4. What are the different components of the tidal power plant? Explain.
5. List out the advantages and disadvantages of a tidal power plant.
6. Discuss the advantages and disadvantages of horizontal and vertical axis wind mills.
7. Define biomass gasification. List different types of biomass gasifiers.
8. What are the factors affecting the biogas generation?
9. What are the risks for the hydrogen energy storage?
10. Describe the power generation from a small hydro power station.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) What are solar collectors? Give their classification and compare them based on construction and area of applications. (10)  
b) Write about any three types of solar cells based on construction materials (4)
12. a) Explain about stand alone and grid connected solar photo voltaic systems (10)  
b) Explain the voltage- current characteristics of a solar cell with neat sketch (4)

**Module II**

13. a) Discuss Explain the basic principle of OTEC. Describe a closed cycle OTEC with its advantages and disadvantages. (10)  
b) What is biofouling? How it affects efficiency of energy conversion and how can it be minimised?. (4)
14. a) What are the different classifications of tidal power plants. Explain the components and detailed working operation of double basin tidal power plant with neat sketch (10)  
b) What are the limitations of the tidal power production? (4)

**Module III**

15. a) What are the different types of generators used with wind turbines? (7)  
b) Derive the expression for the power extracted by a wind turbine. (7)
16. a) What are the advantages and disadvantages of a vertical axis wind turbine system? (7)  
b) Explain the parts, their function and working of a wind power plant. What are the site selection criteria of a wind power. (7)

**Module IV**

17. Explain how urban waste is converted into useful energy .Describe the construction and working of a biogas plant, its material aspects, and utilization of plant products with a neat diagram (14)
18. Explain the advantages and uses of biogas. What are the factors affecting the selection of a particular model of a biogas plant? (14)

**Module V**

19. What are the advantages and applications of hydrogen energy? Explain any two methods of hydrogen production. (14)
20. Explain Explain about the components of a small hydro electric power generation . Draw the layout of a mini hydro project and explain its working (14)



| B24EC3G12 | SCIENTIFIC<br>COMPUTING<br>USING PYTHON | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|-----------------------------------------|---|---|---|---|--------|-------------------------|
|           |                                         | 2 | 1 | 0 | 4 |        |                         |

### Preamble

This course introduces Python programming, covering fundamentals, data structures, control flow, functions, and object-oriented concepts. Students will gain practical skills in data handling, analysis, and visualization using NumPy, Pandas, and Matplotlib, preparing them for problem-solving and scientific computing applications.

### Prerequisites

B24ES1T01A : PROBLEM SOLVING AND PROGRAMMING TECHNIQUES(A)

B24ES1L01A : PROGRAMMING LAB(A)

### Course Outcomes

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand Python basics and develop programs using core constructs. [Understand/Apply]                                                                        |
| <b>CO 2</b> | Develop modular programs using user-defined and built-in functions, including recursion and lambda functions. [Understand,Apply]                               |
| <b>CO 3</b> | Apply NumPy for efficient numerical computation, including array manipulation, linear algebra operations, and solving systems of equations. [Understand,Apply] |
| <b>CO 4</b> | Analyze and visualize data using Matplotlib and Seaborn through various plots and statistical representations.[Understand,Apply,Analyze]                       |
| <b>CO 5</b> | Apply Python libraries (NumPy, Pandas, Matplotlib) to solve real-world problems through case studies involving data and signal processing. [Apply,analyze]     |

### Mapping of Course Outcomes With Program Outcomes

|            | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO1</b> | 3    | 2    | 1    | 1    | 2    | 1    | 1    | 1    | 1    | 1     | 2     |
| <b>CO2</b> | 3    | 3    | 2    | 2    | 3    | 2    | 1    | 1    | 2    | 1     | 2     |
| <b>CO3</b> | 3    | 2    | 3    | 2    | 3    | 2    | 1    | 1    | 2    | 2     | 2     |
| <b>CO4</b> | 2    | 3    | 2    | 3    | 3    | 2    | 1    | 1    | 2    | 2     | 2     |
| <b>CO5</b> | 2    | 2    | 3    | 3    | 3    | 2    | 1    | 2    | 2    | 2     | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 10                    | 10                 | 10                                    |
| Understand       | 30                    | 30                 | 30                                    |
| Apply            | 30                    | 30                 | 30                                    |
| Analyse          | 30                    | 30                 | 30                                    |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Introduction to Python Programming:** Overview of Python: Features, applications, Python basics: Variables, data types, expressions, operators. Control statements: if, for, while, break, continue. Lists, tuples, dictionaries, sets — operations and methods.

### MODULE 2

**Functions in Python:** Functions: Need for functions. Advantages of using functions (modularity, reusability, readability), Function definition and function call, Syntax and structure of a Python function, Built-in functions (e.g., len(), type(), range()). Recursion, Examples of recursive functions (factorial, Fibonacci, sum of numbers), User-defined functions, Anonymous (Lambda) functions

### MODULE 3

**Numpy for Numerical Computation:** Introduction to NumPy arrays: creation, indexing, slicing. Array operations: arithmetic, broadcasting, statistical and mathematical operations. Linear algebra with NumPy: matrix operations, eigenvalues, determinants. Solving systems of linear equations.

### MODULE 4

**Data Visualization and Analysis:** Introduction to Matplotlib: plotting 1D, 2D data, customizing plots. Seaborn and advanced visualizations. Pandas: Series, DataFrame, reading/writing CSV files. Data cleaning, filtering, aggregation, and descriptive statistics.

### MODULE 5

**Applications and Case Studies:** Image and Signal Processing Basics using NumPy :Image representation as arrays, Basic image operations (filtering, transformations, histogram), Simple signal processing tasks (smoothing, convolution, FFT), Case Studies: Population Growth Modeling using numerical methods, Projectile Motion Simulation and visualization, COVID-19 Data Analysis using Pandas Numerical Weather Data Visualization and trend analysis

### Text Books

1. Jaan Kiusalaas, Numerical Methods in Engineering with Python 3, Cambridge University Press.
2. Robert Johansson, Numerical Python: A Practical Techniques Approach for Industry Applications, Apress.
3. Wes McKinney, Python for Data Analysis, O'Reilly.

4. Python for Everybody: Exploring Data in Python 3 – Charles R. Severance, Shroff Publishers and Distributors (SPD), 1st Edition (2017).
5. Hans Petter Langtangen, A Primer on Scientific Programming with Python, Springer.
6. Sandeep Nagar, Introduction to Python for Engineers and Scientists, Apress.



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                        | No of Lecture/Tutorial Hours |
|-----|----------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1: Introduction to Python Programming</b>                                          | <b>8</b>                     |
| 1.1 | Overview of Python – features and applications.                                              | 1                            |
| 1.2 | Python basics: variables, constants, expressions, and operators.                             | 1                            |
| 1.3 | Control statements: <i>if, for, while, break, continue</i> .                                 | 3                            |
| 1.4 | Data structures – lists, tuples, dictionaries, sets: creation, operations, and methods.      | 2                            |
| 1.5 | Input/output operations.                                                                     | 1                            |
|     | <b>Module 2: Functions in Python</b>                                                         | <b>8</b>                     |
| 2.1 | Functions: need, advantages, definition, and call; syntax and structure of Python functions. | 2                            |
| 2.2 | Built-in functions ( <i>len(), type(), range()</i> )                                         | 1                            |
| 2.3 | Recursion and examples ( <i>factorial, Fibonacci, sum of numbers</i> ).                      | 3                            |
| 2.4 | User-defined functions and anonymous (lambda) functions.                                     | 3                            |
|     | <b>Module 3: Data Visualization and Analysis</b>                                             | <b>8</b>                     |
| 3.1 | Introduction to NumPy arrays: creation, indexing, and slicing.                               | 2                            |
| 3.2 | Array operations – arithmetic, broadcasting, statistical, and mathematical operations.       | 2                            |
| 3.3 | Linear algebra with NumPy: matrix operations, eigenvalues, determinants.                     | 2                            |
| 3.4 | Solving systems of linear equations using NumPy.                                             | 2                            |
|     | <b>Module 4: Data Visualization and Analysis</b>                                             | <b>6</b>                     |
| 4.1 | Introduction to Matplotlib: plotting 1D and 2D data, customizing plots.                      | 2                            |
| 4.2 | Advanced visualizations using Seaborn.                                                       | 1                            |
| 4.3 | Pandas: Series and DataFrame – creation, indexing, and manipulation.                         | 2                            |
| 4.4 | Reading and writing CSV files using Pandas.                                                  | 1                            |
| 4.5 | Data cleaning, filtering, aggregation, and descriptive statistics.                           | 2                            |
|     | <b>Module 5: Applications and Case Studies</b>                                               | <b>6</b>                     |
| 5.1 | Image and signal processing basics using NumPy.                                              | 2                            |
| 5.2 | Basic image operations (filtering, transformation, histogram).                               | 1                            |
| 5.3 | Signal processing tasks (smoothing, convolution, FFT).                                       | 1                            |
| 5.4 | Case study: Population growth modeling, projectile motion simulation.                        | 2                            |

|     |                                                                                           |                 |
|-----|-------------------------------------------------------------------------------------------|-----------------|
| 5.5 | Case study: COVID-19 data analysis and numerical weather data visualization using Pandas. | 2               |
|     | <b>Total Hours</b>                                                                        | <b>36 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Write a Python program to find the factorial of a number using functions.
2. Write a Python program to check whether a number is prime using for loop.

#### Course Outcome 2 (CO 2):

1. Write a recursive Python function to generate the Fibonacci series up to n terms.
2. Develop a menu-driven program to compute the area of different shapes (circle, rectangle, triangle) using user-defined functions.

#### Course Outcome 3 (CO 3):

1. Write a program using NumPy to solve a system of linear equations.
2. Explain with code examples how NumPy supports linear algebra operations like matrix multiplication and eigenvalue computation.

#### Course Outcome 4 (CO 4):

1. Write a Python program to visualize student performance data using bar and pie charts.
2. Discuss the data cleaning and aggregation process in Pandas with an example.

#### Course Outcome 5 (CO 5):

1. Develop a Python program for population growth modeling using NumPy and Matplotlib.
2. Perform image smoothing using convolution filters in NumPy and explain the output.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24EC3G12**

**Course Name: SCIENTIFIC COMPUTING USING PYTHON**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. List any four features of Python that make it suitable for scientific computing.
2. Write a Python program to print the even numbers between 1 and 20 using a for loop.
3. What are the advantages of using functions in Python?
4. Write a recursive Python function to find the factorial of a number.
5. Define broadcasting in NumPy. Give an example.
6. Write NumPy commands to find the mean and standard deviation of an array.
7. Differentiate between Matplotlib and Seaborn.
8. What are the different ways to handle missing data in Pandas?
9. What is the use of FFT (Fast Fourier Transform) in signal processing?
10. Mention two real-world applications of Python libraries (NumPy, Pandas, Matplotlib) in data analysis.

**PART B**

**Answer one full question from each module. Each carries 14 marks**

**Module 1**

11. (a) Write a Python program to find the factorial of a number using functions. (8)  
(b) Develop a Python program to perform matrix addition and subtraction using nested lists. (6)

**OR**

12. (a) Write a Python code to find the largest of three numbers using conditional statements. (7)  
(b) Write a Python program to read numbers into a list and find their average. (7)

**Module 2**

13. (a) Write a Python program to demonstrate the use of lambda, map, and filter functions. (7)  
(b) Write a recursive function to compute the Fibonacci sequence up to n terms. (7)

**OR**

14. (a) Explain different types of function arguments in Python with examples. (7)  
(b) Write a Python program to find the sum of all even numbers in a list using functions. (7)

**Module 3**

15. (a) Explain NumPy array creation, slicing, and reshaping with suitable examples. (7)  
(b) Write a Python program to solve a system of linear equations using NumPy. (7)

**OR**

16. (a) Write a Python code to perform matrix addition and subtraction using NumPy arrays. (6)

- (b) Explain various mathematical operations that can be performed using NumPy.(8)

#### **Module 4**

17. (a) Write Python commands to create a Pandas Series and DataFrame. (7)
- (b) Explain how missing data can be handled using Pandas functions. (7)

**OR**

18. (a) Write a Python code to plot a sine and cosine graph using Matplotlib with proper legends. (7)
- (b) Explain how grouped data can be visualized using Pandas and Seaborn. (7)

#### **Module 5**

19. (a) Write a Python program to simulate population growth using NumPy and Matplotlib. (7)
- (b) Explain the steps involved in data visualization and regression analysis using Pandas. (7)

**OR**

20. (a) Develop a Python program to perform basic image processing (smoothing and edge detection) using NumPy. (7)
- (b) Develop a Python program to perform image smoothing using convolution filters in NumPy. (7)

| B24EC3G13 | POWER<br>ELECTRONICS | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|----------------------|---|---|---|---|--------|-------------------------|
|           |                      | 2 | 1 | 0 | 4 |        |                         |

**Preamble**

This course introduces the principles and applications of power electronics for students of non-electrical disciplines. Emphasis is on understanding converter operation, selection of components, and applications in renewable energy, electric vehicles, automation, and computer power systems.

**Prerequisites**

B24ES1T02 : BASICS OF ELECTRICAL & ELECTRONICS ENGINEERING

**Course Outcomes** After completing this course, the student will be able to:

|             |                                                                                                 |
|-------------|-------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Explain the role of power electronics in modern engineering systems. [Understand]               |
| <b>CO 2</b> | Describe the working of basic power semiconductor devices and gate drives. [Understand]         |
| <b>CO 3</b> | Analyze the operation of basic DC–DC, AC–DC, and DC–AC converters. [Understand]                 |
| <b>CO 4</b> | Identify converter applications in drives, renewable energy, and embedded systems. [Understand] |
| <b>CO 5</b> | Discuss emerging technologies like SiC/GaN devices and wireless power. [Understand]             |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 2    |      |      |      | 1    |      |      |      |       |       |
| <b>CO 2</b> | 3    | 2    | 2    |      |      |      |      |      |      |       |       |
| <b>CO 3</b> | 3    | 3    | 2    | 1    | 2    |      |      |      |      |       |       |
| <b>CO 4</b> | 3    | 2    | 1    |      | 2    | 2    |      |      |      |       |       |
| <b>CO 5</b> | 2    |      |      |      | 1    |      |      |      |      |       | 3     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 50                    | 50                 | 50                                    |
| Understand       | 50                    | 50                 | 50                                    |
| Apply            |                       |                    |                                       |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions carrying 3 marks each. Part B contains 2 questions from each module out of which 1 to be answered. Each question carries 14 mark and can have maximum 2 sub- divisions.

## SYLLABUS

### MODULE 1 (7 hours)

**Introduction to Power Electronics:** Role of power electronics in modern systems — renewable energy, EVs, industrial automation, computer power supplies. Power conversion stages and energy flow. Overview of converters — AC–DC, DC–DC, DC–AC, AC–AC.

### MODULE 2 (7 hours)

**Power Semiconductor Devices:** Overview of Power Diode, MOSFET, and IGBT — symbols, characteristics, and switching behavior (qualitative). Gate driving basics and isolation needs. Thermal management and heat sink selection principles.

### MODULE 3 (7 hours)

**DC–DC Converters:** Principle and operation of Buck, Boost, and Buck–Boost converters. Qualitative waveforms. Applications in SMPS and battery charging. Introduction to converter ICs (MC34063, LM2596).

### MODULE 4 (7 hours)

**AC–DC and DC–AC Converters:** Single-phase rectifiers — uncontrolled and controlled (concept only). Inverters — half and full bridge, concept of PWM. UPS and solar inverter examples. Grid interface basics.

### MODULE 5 (8 hours)

**Applications and Emerging Trends:** Motor drives: concept of variable-speed control using inverters. Solar MPPT concept. EV powertrain overview. Introduction to SiC/GaN devices, wireless power transfer, and energy efficiency standards.

### Text Books

1. Umanand L, Power Electronics: Essentials & Applications, Wiley India, 2015
2. Ned Mohan et al., Power Electronics: Converters, Applications, and Design, Wiley.
3. Bimal K. Bose, Modern Power Electronics and AC Drives, Pearson.
4. Rashid, Power Electronics: Circuits, Devices and Applications, Pearson.
5. Philip T. Krein, Elements of Power Electronics, OUP.



**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                                                                                | No of Lecture/Tutorial Hours |
|-----|----------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1 — Introduction to Power Electronics</b>                                                                  | <b>7</b>                     |
| 1.1 | Role of power electronics in modern systems — renewable energy, EVs, industrial automation, computer power supplies. | 2                            |
| 1.2 | Energy conversion stages and power flow — overview of rectifiers, converters, inverters, and choppers.               | 2                            |
| 1.3 | Applications of power electronics in consumer, automotive, and computing domains.                                    | 3                            |
|     | <b>Module 2 — Power Semiconductor Devices</b>                                                                        | <b>7</b>                     |
| 2.1 | Power diode, MOSFET, and IGBT — symbols, switching characteristics (qualitative).                                    | 2                            |
| 2.2 | Gate driving basics and the need for isolation.                                                                      | 2                            |
| 2.3 | Thermal management: junction temperature, heat sinks, and reliability.                                               | 1                            |
| 2.4 | Device selection criteria for low- and medium-power converters.                                                      | 2                            |
|     | <b>Module 3 — DC–DC Converters</b>                                                                                   | <b>7</b>                     |
| 3.1 | Basic principle and operation of Buck, Boost, and Buck–Boost converters.                                             | 2                            |
| 3.2 | Typical waveforms and qualitative analysis (voltage and current).                                                    | 2                            |
| 3.3 | Applications: SMPS, LED drivers, and battery chargers.                                                               | 2                            |
| 3.4 | Introduction to converter ICs — MC34063, LM2596.                                                                     | 1                            |
|     | <b>Module 4 — AC–DC and DC–AC Converters</b>                                                                         | <b>7</b>                     |
| 4.1 | Single-phase rectifiers — uncontrolled and controlled (concept only).                                                | 2                            |
| 4.2 | Inverters — half-bridge and full-bridge configurations.                                                              | 2                            |
| 4.3 | Concept of PWM and harmonic reduction.                                                                               | 2                            |
| 4.4 | Applications: UPS, solar inverter, computer power supplies.                                                          | 1                            |
|     | <b>Module 5 — Applications and Emerging Trends</b>                                                                   | <b>8</b>                     |
| 5.1 | Motor drive basics — variable-speed control using inverters.                                                         | 2                            |
| 5.2 | Introduction to solar MPPT and EV powertrain concepts.                                                               | 2                            |
| 5.3 | SiC and GaN devices — advantages and emerging applications.                                                          | 2                            |
| 5.4 | Wireless power transfer and energy efficiency standards.                                                             | 2                            |
|     | <b>Total Hours</b>                                                                                                   | <b>36 Hours</b>              |

## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1):**

1. Explain the importance of power electronics in modern engineering systems such as electric vehicles, renewable energy, and automation. Give examples of how it impacts efficiency and sustainability.
2. Describe the main types of power converters (AC–DC, DC–DC, DC–AC, AC–AC) and their roles in industrial and consumer applications.

### **Course Outcome 2 (CO 2):**

1. Compare the construction and working principles of a Power Diode, MOSFET, and IGBT. Discuss their relative advantages and areas of application.
2. Explain the purpose of a gate driver circuit and why electrical isolation is important in switching converters. Illustrate with an example.

### **Course Outcome 3 (CO 3):**

1. Explain the operation of Buck and Boost converters with neat circuit diagrams and qualitative waveforms. Identify their typical applications.
2. Discuss how a DC–DC converter IC such as MC34063 or LM2596 simplifies power converter design. Mention its main functional blocks.

### **Course Outcome 4 (CO 4):**

1. Describe the working of a single-phase rectifier and a single-phase inverter. Explain their roles in UPS and solar inverter systems.
2. What is Pulse Width Modulation (PWM)? Explain how PWM helps control inverter output voltage and reduce harmonics.

### **Course Outcome 5 (CO 5):**

1. Explain the basic principle of variable-speed control in motor drives. How do power converters enable speed control in BLDC or induction motors?
2. Write short notes on emerging technologies in power electronics such as SiC/GaN devices and wireless power transfer. Mention one key advantage of each.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 3**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**OPEN ELECTIVE – B TECH DEGREE EXAMINATION, DECEMBER 2024**

**Course Code: B24EC3G13**

**Course Name: POWER ELECTRONICS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 4 marks**

1. Define power electronics and explain its importance in modern engineering systems.
2. List the major types of power converters and their applications.
3. Compare a power diode, MOSFET, and IGBT in terms of control and switching speed.
4. Explain the need for isolation in gate driver circuits.
5. What is the purpose of a heat sink in a power converter?
6. Explain the working principle of a Buck converter.
7. Write short notes on Boost and Buck–Boost converters.
8. What are the main applications of DC–DC converters in embedded and computer systems?
9. Explain the concept of PWM and its significance in inverters.
10. Mention two emerging technologies in power electronics and their advantages.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain the role of power electronics in renewable energy, electric vehicles, and automation systems. (7)  
b) Discuss with block diagrams the different stages of power conversion in a typical electronic system. (7)
12. a) Illustrate with examples how power electronics contributes to energy efficiency in modern devices. (7)  
b) Write short notes on the classification of power converters. (7)

**Module II**

13. a) Describe the structure and working principle of Power Diode, MOSFET, and IGBT. (7)  
b) Explain why gate driver isolation is important in power circuits. Give one practical example. (7)
14. a) Explain the concept of thermal management and the role of heat sinks in converters. (7)  
b) Compare Si, SiC, and GaN devices based on efficiency and switching performance. (7)

**Module III**

15. a) Explain the operation of Buck and Boost converters with neat circuit diagrams and typical applications. (7)  
b) Discuss qualitatively the waveforms of inductor current and switch voltage in a Buck converter. (7)
16. a) Explain how a converter IC such as MC34063 or LM2596 simplifies the design of DC-DC converters. (7)  
b) Write short notes on SMPS and battery charging applications of DC-DC converters. (7)

**Module IV**

17. a) Explain the operation of a single-phase rectifier and its output characteristics. (7)  
b) Describe the working of a single-phase inverter using PWM control. (7)
18. a) Compare uncontrolled and controlled rectifiers in terms of output voltage and applications. (7)  
b) Discuss the role of inverters in UPS and solar inverter systems. (7)

**Module V**

19. a) Explain the basic principle of variable-speed motor drives using inverters. Give two examples of applications. (7)

- b) Describe the concept of Maximum Power Point Tracking (MPPT) in solar systems. (7)
- 20. a) Write short notes on SiC and GaN power devices highlighting their key benefits. (7)
- b) Explain the principle of wireless power transfer and mention its common applications. (7)



| B24EC3G14 | VLSI DESIGN | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|-------------|---|---|---|---|--------|----------------------|
|           |             | 2 | 1 | 0 | 4 | 3      | 2024                 |

**Preamble**

This course introduces students to the fundamentals of Very Large Scale Integration, focusing on CMOS technology, digital logic implementation, circuit behavior, and design principles

**Prerequisites****Course Outcomes**

After completion of the course, the student will be able to:

|             |                                                                                                                                                                                                                   |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the evolution of ICs, types of integration: SSI, MSI, LSI, VLSI, ULSI and GLSI, Moore's law, basics of VLSI design flow, applications and trends in the semiconductor industry. [Remember, Understand] |
| <b>CO 2</b> | Understand the fundamental stages of semiconductor material preparation and key wafer-level processes such as oxidation, diffusion, and epitaxy used in integrated circuit fabrication.[Remember, Understand]     |
| <b>CO 3</b> | Explain the critical device-forming operations, including ion implantation and lithography, and describe how these processes contribute to the overall IC manufacturing flow.[Understand, Analyze]                |
| <b>CO 4</b> | Design static CMOS logic circuits: NAND, NOR, XOR, complex gates, Pass-transistor logic basics and Transmission gates. [Understand, Apply]                                                                        |
| <b>CO 5</b> | Explain the design and operation of different memory cells, including ROM, SRAM and DRAM.[Understand, Apply]                                                                                                      |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 2    | 1    |      | 2    | 2    | 2    |      |      |       | 2     |
| <b>CO 2</b> | 3    | 3    |      | 2    |      | 2    | 2    |      | 1    |       | 2     |
| <b>CO 3</b> | 3    | 2    | 3    | 2    | 3    | 1    | 1    | 2    | 1    | 1     | 2     |
| <b>CO 4</b> | 3    | 2    | 2    |      | 3    |      |      |      |      |       | 2     |
| <b>CO 5</b> | 3    | 3    | 3    | 2    | 3    |      |      |      |      |       | 2     |

**Assessment Pattern**



| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 10                    |                    |                                       |
| Understand       | 80                    | 80                 | 80                                    |
| Apply            |                       | 20                 | 10                                    |
| Analyse          | 10                    |                    | 10                                    |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts: Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module, of which student should answer any one. Each question carries 14 marks and can have maximum 2 subdivisions.

## SYLLABUS

### MODULE 1

**Introduction to VLSI:** Evolution of ICs, types of integration: SSI, MSI, LSI, VLSI, ULSI and GSI, Moore's law, basics of VLSI design flow, design hierarchy, applications and trends in the semiconductor industry.

### MODULE 2

**Fabrication Techniques:** General flow of circuit design procedures, crystal growth (CZ and FZ process), wafer preparations, thermal oxidation, and diffusion used in integrated circuit fabrication.

### MODULE 3

**Fabrication of MOS and CMOS devices:** Epitaxy, ion implantation, metallization techniques and etching used in integrated circuit fabrication. Photolithographic process, fabrication steps of NMOS and CMOS devices.

### MODULE 4

**Static CMOS logic design:** CMOS inverters-DC characteristics, power dissipation, MOS-FET Logic layout-layout of CMOS inverter, two-input NAND and NOR gates. Design of static CMOS logic circuits: NAND, NOR, AND, OR, and implementation of complex functions.

### MODULE 5

**Arithmetic Circuits:** Adder - Full adder (logic diagram), Read Only Memory - 4x4 MOS ROM Cell Arrays(NOR), Random Access Memory –SRAM-Six transistor CMOS cell, DRAM –Three transistors and one transistor Dynamic Memory Cell.

### Text Books

1. Sung –Mo Kang & Yusuf Leblebici, CMOS Digital Integrated Circuits- Analysis & Design, McGraw-Hill, Third Ed., 2003.
2. S.M. SZE, VLSI Technology, 2/e, Indian Edition, McGraw-Hill, 2003
3. Neil H.E. Weste, Kamran Eshraghian, Principles of CMOS VLSI Design- A Systems Perspective, Second Edition. Pearson Publication, 2005.
4. John P Uyemura, Introduction to VLSI Circuits and Systems, Wiley India, 2006
5. Jan M.Rabaey, Digital Integrated Circuits- A Design Perspective, Prentice Hall, Second Edition, 2005.
6. Razavi - Design of Analog CMOS Integrated Circuits, 1e, McGraw Hill Education India Education, New Delhi 2003

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                                     | No of Lecture/Tutorial Hours |
|-----|---------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                           | <b>6</b>                     |
| 1.1 | Introduction to VLSI                                                      | 1                            |
| 1.2 | Evolution of ICs, types of integration: SSI, MSI, LSI, VLSI, ULSI and GSI | 1                            |
| 1.3 | Moore's law and its importance                                            | 1                            |
| 1.2 | Design hierarchy                                                          | 1                            |
| 1.3 | Real life applications of VLSI                                            | 1                            |
| 1.4 | Trends in the semiconductor industry.                                     | 1                            |
|     | <b>Module 2</b>                                                           | <b>7</b>                     |
| 2.1 | General flow of circuit design procedures                                 | 2                            |
| 2.2 | Crystal growth (CZ process)                                               | 1                            |
| 2.2 | wafer preparations, thermal oxidation                                     | 2                            |
| 2.3 | Diffusion process                                                         | 2                            |
|     | <b>Module 3</b>                                                           | <b>9</b>                     |
| 3.1 | Epitaxy and Ion implantation and metallization                            | 3                            |
| 3.1 | Etching - dry and wet etching                                             | 2                            |
| 3.3 | Photolithography                                                          | 1                            |
| 3.4 | Fabrication process of NMOS transistor                                    | 1                            |
| 3.5 | Fabrication process of PMOS transistor                                    | 1                            |
| 3.6 | Fabrication process of CMOS transistor                                    | 1                            |
|     | <b>Module 4</b>                                                           | <b>6</b>                     |
| 4.1 | CMOS inverter and its DC characteristics                                  | 2                            |
| 4.2 | Power dissipation of CMOS inverter                                        | 1                            |
| 4.3 | Layout of CMOS inverter, two-input NAND, two-input NOR gates and          | 2                            |
| 4.4 | Implementation of complex logic functions.                                | 1                            |
|     | <b>Module 5</b>                                                           | <b>7</b>                     |
| 5.1 | Adders: Full adder logic diagram                                          | 1                            |
| 5.2 | Read only memory -4x4 MOS ROM cell array                                  | 2                            |
| 5.3 | Random access memory - SRAM -six transistor cell                          | 2                            |
| 5.4 | DRAM -Three-transistor and One-transistor Dynamic Memory Cell.            | 2                            |
|     | <b>Total Hours</b>                                                        | <b>35 Hours</b>              |

**CO ASSESSMENT QUESTIONS**

**Course Outcome 1 (CO 1):**

1. Describe the evolution of Integrated Circuits (ICs) starting from SSI to GSI. How did each stage contribute to the advancement of semiconductor technology?
2. State Moore's Law.
3. Illustrate the basic VLSI design flow. Briefly explain each step involved from system specification to fabrication.

**Course Outcome 2 (CO 2):**

1. Compare CZ growth technique and FZ growth technique.
2. List and explain the major steps involved in silicon wafer preparation.
3. Explain the thermal oxidation process and the difference between dry and wet oxidation.
4. Explain the principle of diffusion in the IC fabrication process.

**Course Outcome 3 (CO 3):**

1. Explain the photolithographic process.
2. Illustrate the steps involved in the fabrication of NMOS transistors.
3. Explain the fabrication process of a CMOS transistor.

**Course Outcome 4 (CO 4):**

1. Draw the DC transfer characteristics of a CMOS inverter.
2. Design a two-input NAND gate using CMOS logic and draw the stick diagram.
3. Explain transmission gate logic with circuit diagrams.

**Course Outcome 5 (CO 5):**

1. Explain the working of the 6T CMOS SRAM cell with necessary circuit diagram.
2. Differentiate between SRAM and DRAM.
3. Explain the design of 4x4 MOS ROM Cell Arrays.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2028**

**Course Code: B24EC3G14**

**Course Name: VLSI DESIGN**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Write a short note on the evolution of ICs.
2. State Moore's Law. Discuss its significance in the semiconductor industry.
3. Compare Czochralski (CZ) and Float Zone (FZ) crystal growth techniques.
4. What are the factors affecting oxide growth rate in silicon oxidation?
5. What are the factors affecting oxide growth rate in silicon oxidation?
6. What is epitaxy? Mention its importance in IC fabrication.
7. Explain PUN (Pull-Up Network) and PDN (Pull-Down Network) in CMOS logic.
8. Sketch the layout of a two-input CMOS NAND gate.
9. Draw the logic diagram of a full adder and write its Boolean expressions.
10. Compare SRAM and DRAM based on structure and operation.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Compare top-down and bottom-up design methodologies in VLSI design. (7)  
b) Discuss the emerging trends in the semiconductor industry. (7)
12. a) Describe the importance of design hierarchy and abstraction levels in the VLSI design process. (7)  
b) Classification of ICs Based on Integration Level. (7)

**Module II**

13. a) Explain the Czochralski (CZ) crystal growth process with a neat diagram. (14)
14. a) Discuss the role of diffusion and thermal oxidation in MOSFET fabrication. (7)  
b) Discuss the importance of the SiO<sub>2</sub> layer in IC Fabrication. (7)

**Module III**

15. a) Describe the epitaxial growth process and its importance in MOS and CMOS fabrication. (7)  
b) Compare wet etching and dry etching processes. (7)
16. a) Describe the detailed fabrication steps of a CMOS device. (14)

**Module IV**

17. a) Design a CMOS circuit to implement the function  $F = A BC + AB + CD$ , and draw the CMOS logic diagram. (7)  
b) Draw the circuit diagram and layout of a two-input CMOS NAND gate. (7)
18. a) Explain the structure and working of a transmission gate. Implement 4×1 multiplexer using transmission gates. (7)  
b) Why PMOS transistors can pass only strong ones, and NMOS transistors can pass strong zeros. (7)

**Module V**

19. Describe the read operation of a six-transistor CMOS SRAM cell. (14)
20. Explain the read and write operations of a three-transistor DRAM cell. (14)



| B24EC3G15 | EMBEDDED SYSTEMS | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|------------------|---|---|---|---|--------|----------------------|
|           |                  | 2 | 1 | 0 | 4 | 3      | 2025                 |

**Preamble**

This course introduces the fundamentals of embedded systems for students from non-electronics backgrounds. It provides an understanding of embedded system components, microcontrollers, memory systems, interfacing, and real-time operating systems. The course also includes exposure to IoT, ARM architecture, and recent embedded technologies.

**Prerequisites**

Nil

**Course Outcomes**

After the completion of the course, the student will be able to:

|      |                                                                                                        |
|------|--------------------------------------------------------------------------------------------------------|
| CO 1 | Understand the fundamentals and building blocks of embedded systems.[Understand,Apply]                 |
| CO 2 | Explain micro-controller architecture and functional units. [Remember, Understand]                     |
| CO 3 | Develop simple assembly language programs. [Understand, Apply]                                         |
| CO 4 | Analyze memory organization and its management in embedded systems. [Understand, Apply]                |
| CO 5 | Familiarize system software and advanced architectures (ARM and RTOS concepts). [Remember, Understand] |

**Mapping of Course Outcomes With Program Outcomes**

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 1    | 1    | 1    | 1    | 2    | 1    |      |      |       | 3     |
| CO 2 | 3    | 1    | 1    | 1    | 1    | 1    | 1    |      |      |       | 3     |
| CO 3 | 3    | 3    | 3    | 3    | 3    | 3    | 2    | 1    | 1    |       | 3     |
| CO 4 | 3    | 2    | 2    | 2    | 2    | 2    | 1    |      |      |       | 3     |
| CO 5 | 3    | 1    | 2    | 1    | 1    | 2    | 1    |      |      |       | 3     |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 30                    | 30                 | 30                                    |
| Apply            | 50                    | 50                 | 50                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## **SYLLABUS**

### **MODULE 1**

**Fundamentals of Embedded Systems:** Introduction, Definition, characteristics, and applications of embedded systems; Hardware–software–firmware components; Embedded system design process; Use cases: Smart Home Devices, Automotive Control, Consumer Electronics.

### **MODULE 2**

**Microcontrollers and Programming :** Overview of Microcontroller Architecture; Difference between microcontrollers and microprocessors, Embedded Processors; Microcontroller Architecture – Block diagram of 8051, Pin configuration, Registers, Internal Memory, Timers, Port Structures, Interrupts. Assembly Language Programming - Addressing Modes, Instruction set (Detailed study of 8051 instruction set is not required, only classification with examples and required for next module).

### **MODULE 3**

**Interfacing and Communication with Peripherals:** Simple programming examples in assembly language in 8051. Interfacing with 8051 using Assembly language programming: LED, Seven segment LED display. Simple examples – delay generation, port programming, code conversion. Interfacing of – LCD display and Keyboard programming.

### **MODULE 4**

**Memory System :** Memory Organization in microcontrollers, Types of memory - RAM, ROM. Memory Characteristics and Hierarchy. Cache memory – The basics of Caches, Mapping techniques, Improving Cache performance. Virtual memory –Overlay, Memory management, Address translation. Input/Output Organization –Introduction, Synchronous vs. asynchronous I/O, Programmed I/O, Interrupt driven I/O, Direct Memory Access.

### **MODULE 5**

**Real-Time Operating Systems and Advanced concepts :** Software aspects of embedded systems: Real Time Operating Systems for Embedded Systems – requirements, kernel types, scheduling, context switching, latency, inter-task communication and synchronization; Introduction to ARM – ARM family, ARM 7 register architecture. ARM programmer's model. System software - Assembler, Interpreter, Compiler, Linker, Loader, Debugger.

**Text Books**

1. Raj Kamal, Embedded Systems: Architecture, Programming and Design, McGraw Hill.
2. Muhammed Ali Mazidi & Janice Gilli Mazidi, R.D. Kinley, The 8051 microcontroller and Embedded System, Pearson Education, 2nd edition.
3. K.V. Shibu, Introduction to Embedded Systems, 2e, McGraw Hill Education India, 2016.
4. Steve Furber, ARM system-on-chip architecture, Addison Wesley, Second Edition, 2000.
5. David E. Simon, An Embedded Software Primer, Pearson Education Asia, First Indian Reprint 2000.
6. Steve Heath, Embedded Systems Design, Newnes – Elsevier 2ed, 2002.
7. Andrew N. Sloss, Dominic Symes, Chris Wright, ARM System Developer's Guide Designing and Optimizing System Software, Morgan Kaufmann Publishers 2004.
8. The 8051 Microcontrollers: Architecture Programming and Applications, K Uma Rao & Andhe Pallavi, Pearson, 2011.
9. Stallings W., Computer Organisation and Architecture, 5/e, Pearson Education.
10. Computer organization and design: The Hardware/Software interface/David A. Patterson, John L. Hennessy. — 5th ed .

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                                                                                                                               | No of Lecture/Tutorial Hours |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                                     | <b>8</b>                     |
| 1.1 | Definition, characteristics, and applications of embedded systems.                                                                                                  | 2                            |
| 1.2 | Components: Hardware, Software, and Firmware.                                                                                                                       | 2                            |
| 1.3 | Embedded System Design Process.                                                                                                                                     | 1                            |
| 1.4 | Examples: Smart Home Devices, Automotive Control, Consumer Electronics.                                                                                             | 3                            |
|     | <b>Module 2</b>                                                                                                                                                     | <b>8</b>                     |
| 2.1 | Overview of Microcontroller Architecture; Difference between microcontrollers and microprocessors, Embedded Processors;.                                            | 1                            |
| 2.2 | Microcontroller Architecture – Block diagram of 8051, Pin configuration.                                                                                            | 1                            |
| 2.3 | Registers, Internal Memory, Timers, Port Structures, Interrupts.                                                                                                    | 2                            |
| 2.4 | Assembly Language Programming - Addressing Modes, Instruction set.                                                                                                  | 4                            |
|     | <b>Module 3</b>                                                                                                                                                     | <b>9</b>                     |
| 3.1 | Simple programming examples in assembly language in 8051.                                                                                                           | 2                            |
| 3.2 | Interfacing with 8051 using Assembly language programming: LED, Seven segment LED display.                                                                          | 2                            |
| 3.3 | Simple examples – delay generation, port programming, code conversion.                                                                                              | 2                            |
| 3.4 | Interfacing of – LCD display and Keyboard programming.                                                                                                              | 3                            |
|     | <b>Module 4</b>                                                                                                                                                     | <b>8</b>                     |
| 4.1 | Memory Organization in microcontrollers, Types of memory - RAM, ROM.                                                                                                | 2                            |
| 4.2 | Types of memory - RAM, ROM. Memory Characteristics and Hierarchy. Cache memory – The basics of Caches, Mapping techniques, Improving Cache performance.             | 2                            |
| 4.3 | Virtual memory –Overlay, Memory management, Address translation.                                                                                                    | 1                            |
| 4.4 | Input/Output Organization –Introduction, Synchronous vs. asynchronous I/O, Programmed I/O, Interrupt driven I/O, Direct Memory Access. .                            | 3                            |
|     | <b>Module 5</b>                                                                                                                                                     | <b>9</b>                     |
| 5.1 | Software aspects of embedded systems.                                                                                                                               | 1                            |
| 5.2 | Real Time Operating Systems for Embedded Systems – requirements, kernel types, scheduling, context switching, latency, inter-task communication and synchronization | 3                            |

|     |                                                                                        |                 |
|-----|----------------------------------------------------------------------------------------|-----------------|
| 5.3 | Introduction to ARM – ARM family, ARM 7 register architecture. ARM programmer's model. | 2               |
| 5.4 | System software - Assembler, Interpreter, Compiler, Linker, Loader, Debugger.          | 3               |
|     | <b>Total Hours</b>                                                                     | <b>42 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the fundamental characteristics of embedded systems with suitable examples. Discuss how the constraints on performance, power consumption, memory, and real-time operation influence the design choices in embedded systems.
2. Describe the complete embedded system design process. Illustrate the hardware, software, and firmware components involved, and explain how these elements interact during the development of real-world embedded applications such as smart home devices or automotive controllers.

#### Course Outcome 2 (CO 2):

1. Draw and describe the architectural block diagram of the 8051 microcontroller. Explain the function of each major unit including ALU, ports, memory organization, timers, and interrupt system. How do these features support embedded system implementation.
2. Explain the different addressing modes supported by 8051 with suitable examples. Illustrate how the selection of an addressing mode affects program efficiency and memory usage in microcontroller-based applications.

#### Course Outcome 3 (CO 3):

1. Write and explain an assembly language program for 8051 to interface and control a seven-segment display. Discuss the step-by-step approach used for port programming, decoding, and delay generation required for stable display operation.
2. With the help of suitable diagrams, explain the interfacing techniques of LCD modules and keyboard matrices with 8051. Develop an assembly-level flow explaining how key scanning, debouncing, and LCD command/data operations are performed.

#### Course Outcome 4 (CO 4):



1. Discuss the hierarchy of memory in embedded systems. Explain in detail the mapping techniques of cache memory (direct, associative, and set-associative) and analyze how cache performance can be improved using modern embedded processor design strategies.
2. Explain the concept of virtual memory in embedded systems. Discuss the role of DMA, interrupt-driven I/O, and synchronous/asynchronous I/O in optimizing memory and I/O performance.

**Course Outcome 5 (CO 5):**

1. Describe in detail the essential requirements of a Real-Time Operating System (RTOS). Explain how RTOS characteristics influence real-time embedded system performance..
2. Discuss the ARM architecture with emphasis on ARM7 register organization and programmer's model.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24EC3G15**

**Course Name: EMBEDDED SYSTEMS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define an embedded system with examples?
2. Give the components of an embedded system.
3. Draw the block diagram of 8051.
4. Explain immediate and register addressing modes with example.
5. Write an assembly language program(ALP) to toggle P1.0.
6. Differentiate the instructions PUSH and POP.
7. Define Cache memory.
8. Explain the significance of DMA.
9. List system software tools used in embedded development
10. Draw ARM7 register set.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain embedded system design process. (10)  
b) List the characteristics of embedded systems. (4)
12. a) 12. Explain hardware, software, and firmware components of embedded systems in detail. (14)

**Module II**

13. a) Explain the architecture of 8051 microcontroller with diagram. (10)  
b) Explain 8051 interrupt structure.. (4)
14. a) Give an account of timers and port operations in 8051 (14)

**Module III**

15. a) Discuss keyboard interfacing with 8051. (14)
16. a) Write an ALP to display numbers 0–9 on a 7-segment display. (10)  
b) Draw the flowchart of LCD interfacing steps. (4)

**Module IV**

17. a) Explain cache memory mapping techniques. (8)  
b) Brief a note on Virtual memory and its use.. (6)
18. Compare programmed I/O, interrupt I/O, and DMA. . (14)

**Module V**

19. Explain the RTOS process synchronization mechanisms and inter task communication. (14)
20. Explain the role of assembler, compiler, linker, loader, and debugger in embedded systems. (14)

| B24EC3L09 | DIGITAL SIGNAL<br>PROCESSING<br>LAB | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|-------------------------------------|---|---|---|---|--------|-------------------------|
|           |                                     | 0 | 0 | 3 | 2 | 2      | 2024                    |

### Preamble

This laboratory introduces practical aspects of discrete-time signal processing. Students learn to generate, understand and analyze signals, verify DFT properties, perform convolution operations, and design FIR and IIR filters.

### Prerequisite

B24EC2T05 : SIGNALS AND SYSTEMS

B24EC3T01 : DIGITAL SIGNAL PROCESSING

### Course Outcomes

After the completion of the course the student will be able to

|             |                                                                                                                                                            |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Demonstrate the generation and perform basic operations of discrete-time signals using Python and DSP hardware platforms. [Apply]                          |
| <b>CO 2</b> | Apply the Discrete Fourier Transform (DFT) to analyze frequency-domain characteristics and verify its properties. [Apply]                                  |
| <b>CO 3</b> | Implement linear convolution techniques using Overlap-Add and Overlap-Save methods for efficient signal processing. [Apply]                                |
| <b>CO 4</b> | To acquire hands-on experience in implementing DSP algorithms and perform modulation-related experiments to understand real-time DSP applications. [Apply] |
| <b>CO 5</b> | Design and realize FIR and IIR digital filters to meet specified frequency response characteristics [Apply]                                                |

### Mapping of Course Outcomes With Program Outcomes

|             | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| <b>CO 1</b> | 3   | 2   | 2   | 2   | 2   |     |     |     | 1   | 2    | 1    |
| <b>CO 2</b> | 3   | 3   | 2   | 2   | 2   |     |     |     |     | 2    | 1    |
| <b>CO 3</b> | 3   | 3   | 2   | 2   | 2   |     |     |     | 1   | 2    | 1    |
| <b>CO 4</b> | 3   | 3   | 3   | 2   | 3   |     |     |     |     | 2    | 1    |
| <b>CO 5</b> | 3   | 2   | 2   | 2   | 2   |     |     |     | 1   | 2    | 1    |

## Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hour       |

## Continuous Internal Evaluation Pattern

|                       |          |
|-----------------------|----------|
| Attendance            | 10 marks |
| Continuous Assessment | 20 marks |
| Internal Test         | 20 marks |

## End semester Examination pattern

|                                |          |
|--------------------------------|----------|
| Preliminary Work               | 30 marks |
| Performance and Implementation | 20 marks |
| Result and Inference           | 30 marks |
| Viva                           | 20 marks |

## SYLLABUS

### LIST OF EXPERIMENTS

#### PART-A: Simulation Experiments (Any 5)

|   |                                                                                                                                                                                                                                            |
|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Generation of signals and performing signal operations:<br>1. Addition of two signals.<br>2. Multiplication of two signals.                                                                                                                |
| 2 | Verification of DFT properties:<br>1. Verify the properties of the Discrete Fourier Transform (DFT) – linearity, time shifting, Parseval's theorem, and conjugate symmetry.<br>2. Perform circular convolution of two sequences using DFT. |
| 3 | Linear convolution using the Overlap-Add method.                                                                                                                                                                                           |
| 4 | Linear convolution using the Overlap-Save method.                                                                                                                                                                                          |
| 5 | Verification of the Sampling Theorem.                                                                                                                                                                                                      |
| 6 | Implementation and verification of the Inverse Fast Fourier Transform (IFFT) using the FFT algorithm.                                                                                                                                      |
| 7 | Design a Finite Impulse Response (FIR) low-pass filter using a windowing method and obtain its frequency response by passing sinusoidal inputs.                                                                                            |
| 8 | Design a low-pass Butterworth Infinite Impulse Response (IIR) filter and obtain its frequency response by passing sinusoidal inputs.                                                                                                       |

#### PART-B: Hardware Experiments (Any 5)

|   |                                                                                                                                                 |
|---|-------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Hardware familiarization: LED blinking using a switch.                                                                                          |
| 2 | Generation of standard signals.                                                                                                                 |
| 3 | Linear convolution of two sequences using circular convolution.                                                                                 |
| 4 | Verification of the Nyquist sampling theorem.                                                                                                   |
| 5 | Design a finite impulse response (FIR) low pass filter using a windowing method and obtain its frequency response by passing sinusoidal inputs. |
| 6 | Design an IIR Butterworth filter, obtain its frequency response by passing sinusoidal inputs at various frequencies.                            |
| 7 | Implement a DSB-SC modulator.                                                                                                                   |

### Reference Books

1. Emmanuel C. Ifeache, Barry W. Jervis, Digital Signal Processing: A Practical Approach, 2nd Edition, Pearson Education, 2004.
2. John G. Proakis, Dimitris G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, 4th Edition, Pearson India, 2007.
3. Oppenheim A. V., Schafer R. W, Digital Signal Processing, Pearson India, 2015.
4. Boaz Porat, A Course in Digital Signal Processing, Wiley India Pvt. Ltd., 2012.
5. Downey, Allen B. Think Python: How to Think Like a Computer Scientist, 2nd ed., O'Reilly Media, 2015.
6. LPC 1769 datasheet
7. STM32F4431 datasheet



| B24EC3L10 | MINIPROJECT | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|-------------|---|---|---|---|--------|----------------------|
|           |             | 0 | 0 | 3 | 2 | 2      | 2024                 |

### Preamble

- To estimate the ability of the students in transforming the theoretical knowledge studied in to a working model of an electronic system.
- For enabling the students to gain experience at organization and implementation of small projects.
- Design and development of small electronic project based on hardware or a combination of hardware and software for electronics system.

### Course Plan

In this course, each group consisting of three to four students is required to design and develop a moderately complex electronic system with practical, real-world applications. The outcome should be a fully functional working model, incorporating the fundamental principles of product design.

Students must select a topic of interest in consultation with the assigned faculty advisor. They should conduct a literature review and gather relevant information related to the chosen topic. Based on this, the objectives must be clearly defined, and an appropriate methodology should be developed to achieve them. The project may involve circuit/system design, hardware fabrication, software development, or coding—depending on the nature of the work. The novelty and uniqueness of the proposed project should be demonstrated through measurable results and outputs.

Progress will be evaluated through a minimum of two reviews conducted by a committee constituted by the Head of the Department. At the end of the semester, students are required to submit a comprehensive project report prepared in  $\text{\LaTeX}$  and demonstrate the product according to its complete design specifications. Projects that exhibit innovative design concepts, reliability, aesthetics, and ergonomic considerations will be given additional weightage.

### Evaluation

The internal evaluation will be made based on the product, the report and a viva-voce examination, conducted by a 3-member committee appointed by the Head of the Department comprising HoD or a senior faculty member, Academic coordinator for the Program, project guide/coordinator.

The committee will be evaluating the level of completion and demonstration of functionality/specifications, presentation, oral examination, work knowledge and involvement.

### Course Outcomes

After the completion of the course the student will be able to

|             |                                                                                                                           |
|-------------|---------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Be able to practice acquired knowledge within the selected area of technology for project development. [Apply]            |
| <b>CO 2</b> | Identify, discuss and justify the technical aspects and design aspects of the project with a systematic approach. [Apply] |
| <b>CO 3</b> | Reproduce, improve and refine technical aspects for engineering projects. [Apply]                                         |
| <b>CO 4</b> | Work as a team in development of technical projects. [Apply]                                                              |
| <b>CO 5</b> | Communicate and report effectively project related activities and findings. [Apply]                                       |

### Mapping of Course Outcomes With Program Outcomes

|             | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> |
|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|
| <b>CO 1</b> | 3          | 3          | 3          | 2          |            | 3          |            |            | 3          | 1           |             |
| <b>CO 2</b> | 3          | 3          | 3          | 2          | 1          | 3          |            |            | 3          | 1           | 1           |
| <b>CO 3</b> | 3          | 3          | 3          | 2          |            | 3          | 1          |            |            |             | 1           |
| <b>CO 4</b> |            |            |            |            | 1          |            | 1          | 3          |            | 1           |             |
| <b>CO 5</b> |            |            |            |            | 1          |            | 1          |            | 3          | 1           |             |

### Mark Distribution

|                    |                  |                  |                     |
|--------------------|------------------|------------------|---------------------|
| <b>Total Marks</b> | <b>CIE Marks</b> | <b>ESE Marks</b> | <b>ESE Duration</b> |
| 150                | 50               | 100              | 1 hour              |

### Continuous Internal Evaluation Pattern

|                                           |          |
|-------------------------------------------|----------|
| Attendance                                | 10 marks |
| Marks awarded based on guide's evaluation | 10 marks |
| Project Report                            | 10 marks |
| Evaluation by Committee                   | 20 marks |

### End semester Examination pattern

|                                |          |
|--------------------------------|----------|
| Level of Completion            | 20 marks |
| Demonstration of functionality | 20 marks |
| Project Report                 | 20 marks |
| Viva - voce                    | 30 marks |
| Presentation                   | 10 marks |

| B24ECM61 | VLSI CIRCUITS<br>(Minor) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|----------|--------------------------|---|---|---|---|--------|-------------------------|
|          |                          | 3 | 1 | 0 | 5 | 4      | 2024                    |

### Preamble

This course aims to impart the knowledge about the fundamentals of Digital Systems, MOS-FETs, basic VLSI circuits, and Application Specific Integrated Circuits.

### Prerequisites

ECT281: Electronic Circuits

### Course Outcomes

After the completion of the course the student will be able to:

|      |                                                                                                                                             |
|------|---------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Explain the working of various functional building blocks used in digital system design                                                     |
| CO 2 | Explain Structure and working of MOSFETS and basic VLSI circuits using MOS-FET                                                              |
| CO 3 | Explain the circuit technique used to implement dynamic logic and storage cells                                                             |
| CO 4 | Explain the application specific integrated circuit design flow and design approached                                                       |
| CO 5 | Explain the programmable logic cells, programming technologies, different type of i/o cells and different timing constraints in ASIC design |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    | 3    |      |      |      |      |      |      |       | 3     |
| CO 2 | 3    | 2    | 2    |      | 1    |      |      |      |      |       | 3     |
| CO 3 | 3    | 2    | 2    |      | 1    |      |      |      |      |       | 3     |
| CO 4 | 3    | 3    | 3    |      | 3    |      |      |      |      |       | 3     |
| CO 5 | 3    | 3    | 3    |      | 3    |      |      |      |      |       | 3     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 15                    | 15                 | 30                                    |
| Understand       | 25                    | 25                 | 50                                    |
| Apply            | 10                    | 10                 | 20                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## **SYLLABUS**

### **MODULE 1**

**Basic Building Blocks in Digital Systems (12 Hrs):** Basic logic gates, binary adder, subtractor, magnitude comparator, decoders, encoders, multiplexers, simple examples for combinational circuits (discuss with respective truth tables) Sequential circuits, Latched and flip-flops, clocked sequential circuits, registers, shift registers, counters (analysis not required)

### **MODULE 2**

**MOSFET Fundamentals and basic VLSI circuits (9 Hrs):** Structure and working principle of MOSFETS, VI characteristics, current equations (derivations not required), NMOS and CMOS inverter circuits, static characteristics and comparison, implementation of CMOS logic gates, stick diagram representation, Layout Design and Design rules- Lambda rules and micron rules (Definitions only).

### **MODULE 3**

**Dynamic logic Design and Storage Cells (8 Hrs):** Dynamic Logic Design-Pre charge-Evaluate logic, Domino Logic, NP domino logic. Read Only Memory-4x4 MOS ROM Cell Arrays (NOR) Random Access Memory –SRAM-Six transistor CMOS SRAM cell, DRAM –Three transistor and One transistor Dynamic Memory Cell.

### **MODULE 4**

**VLSI Design Methodologies (7 Hrs):** Introduction: Moore slow .ASIC design, Full custom ASICs, Standard cell based ASICs, Gate array based ASICs, SoCs, FPGA devices, ASIC and FPGA Design flows Top-Down and Bottom-Up design methodologies. Logical and Physical design. Speed power and area considerations in VLSI design

### **MODULE 5**

**FPGA Architecture(8 Hrs):** Programmable logic cells: multiplexer based logic cells(ACT1), lookup table based logic implementation(XC3000 CLB), programmable array based logic implementation (Altera MAX). ASIC programming technologies: antifuse, SRAM, EPROM, EEPROM Different types of I/O cells used in programmable ASICs Timing constraints in ASIC design: setup time, hold time, propagation delay, clock to output delay, critical path (concept only)

**Text Books**

- 1.M. Morris Mano, Digital Design 3/e, Prentice Hall of India, 2002.
2. M. J. S. Smith, Application Specific Integrated Circuits, Pearson Education,2007
- 3.Sung Mo Kang and Yusuf Leblebici, CMOS Digital Integrated Circuits- Analysis and Design, McGraw-Hill, Third Ed., 2003

**References**

- 1.Thomas Floyds, Digital Fundamentals, 11th edition, Pearson Publication, 2015
2. Neil H.E. Weste, Kamran Eshraghian, Principles of CMOS VLSI Design- A Systems Perspective, Second Edition. Pearson Publication, 2005.
3. Jan M. Rabaey, Digital Integrated Circuits- A Design Perspective, Prentice Hall, Second Edition, 2005.





**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                                                                                    | <b>No of Lecture/Tutorial Hours</b> |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1: Basic Building Blocks in Digital Systems</b>                                                                                                                       | <b>12</b>                           |
| 1.1       | Basic logic gates,                                                                                                                                                              | 1                                   |
| 1.2       | binary adder, subtractor                                                                                                                                                        | 2                                   |
| 1.3       | magnitude comparator, decoders, encoders.                                                                                                                                       | 1                                   |
| 1.4       | multiplexers, simple examples for combinational circuits.                                                                                                                       | 2                                   |
| 1.5       | Sequential circuits, Latches and flip-flops.                                                                                                                                    | 2                                   |
| 1.6       | clocked sequential circuits, registers, shift registers, counters                                                                                                               | 4                                   |
|           | <b>Module 2:MOSFET Fundamentals and basic VLSI circuits</b>                                                                                                                     | <b>9</b>                            |
| 2.1       | Structure and working principle of MOSFETS.                                                                                                                                     | 1                                   |
| 2.2       | VI characteristics, current equations.                                                                                                                                          | 1                                   |
| 2.3       | NMOS and CMOS inverter circuits, static characteristics and comparison.                                                                                                         | 3                                   |
| 2.4       | Implementation of CMOS logic gates.                                                                                                                                             | 2                                   |
| 2.5       | Stick diagram representation, Layout Design and Design rules- Lambda rules and micron rules (Definitions only).                                                                 | 2                                   |
|           | <b>Module 3: Dynamic logic Design and Storage Cells</b>                                                                                                                         | <b>7</b>                            |
| 3.1       | Dynamic Logic Design-Pre charge- Evaluate logic                                                                                                                                 | 1                                   |
| 3.2       | Domino Logic, NP domino logic                                                                                                                                                   | 2                                   |
| 3.3       | ROM, Ram and DRAM.                                                                                                                                                              | 4                                   |
|           | <b>Module 4: VLSI Design Methodologies</b>                                                                                                                                      | <b>8</b>                            |
| 4.1       | Introduction: Moore slaw .ASIC design.                                                                                                                                          | 1                                   |
| 4.2       | Full custom ASICs, Standard cell based ASICs, Gate array based ASICs, SoCs, FPGA devices.                                                                                       | 3                                   |
| 4.3       | ASIC and FPGA Design flows Top-Down and Bottom-Up design methodologies.                                                                                                         | 2                                   |
| 4.4       | 4.4 Logical and Physical design. Speed power and area considerations in VLSI design.                                                                                            | 2                                   |
|           | <b>Module 5: FPGA Architecture</b>                                                                                                                                              | <b>9</b>                            |
| 5.1       | Programmable logic cells: multiplexer based logic cells(ACT1), lookup table based logic implementation(XC3000 CLB), programmable array based logic implementation (Altera MAX). | 3                                   |
| 5.2       | ASIC programming technologies: antifuse, SRAM, EPROM, EEPROM                                                                                                                    | 2                                   |
| 5.3       | Different types of I/O cells used in programmable ASICs.                                                                                                                        | 2                                   |
| 5.4       | Timing constraints in ASIC design: setup time, hold time, propagation delay, clock to output delay, critical path.                                                              | 2                                   |
|           | <b>Total Hours</b>                                                                                                                                                              | <b>45 Hours</b>                     |

## CO ASSESSMENT QUESTIONS

### Course Outcome 1 (CO 1):

1. With circuit and truth table, explain the working of a full adder.
2. Explain the use of 2m:1 multiplexer for realizing a logic function of m variables.
3. With circuit and truth table, explain the working of a 4 bit ripple counter

### Course Outcome 2 (CO 2):

1. Draw the structure of a n-channel MOSFET and describe its working.
2. Explain the static characteristics of NMOS inverter and derive its pull up to pull down impedance ratio
3. Draw the circuit diagram of two input NAND gate in CMOS logic and represent it using its stick diagram

### Course Outcome 3 (CO 3):

1. Describe the basic principle of dynamic logic with the necessary diagrams
2. Explain the working of np domino logic. What are its merits and demerits over domino logic?
3. Explain the working of one transistor Dynamic Memory Cell.

### Course Outcome 4 (CO 4):

1. Explain and compare the full custom and semicustom IC design methods
2. Describe the Top-Down and Bottom-Up design methodologies using in ASIC design
3. Discuss the Speed power and area considerations in VLSI design

### Course Outcome 5 (CO 5):

1. Explain a multiplexer based programmable logic cells
2. Describe the programmable array based logic implementation in Altera MAX
3. Define setup time, hold time, propagation delay, clock to output delay

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2026**

**Course Code: B24ECM61**

**Course Name: VLSI CIRCUITS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Which are the universal gates and why are they called as universal gates?
2. Draw the circuit diagram to realize a modulo 15 down counter
3. Draw VI characteristics of n- channel MOSFET and clearly mark different regions
4. Define lambda rules and micron rules.
5. List out the merits and drawbacks of np domino over domino logic
6. Explain the working of one transistor Dynamic Memory Cell.
7. Explain Moore slow in VLSI design
8. Differentiate between full custom and semicustom design methods in ASIC design.
9. List different types of I/O cells used in programmable ASICs.
10. What is mean by critical path in an ASIC?

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) With circuit and truth table, explain the working of a full adder. Also draw the schematic of 4 bit binary adder using full adder blocks (8)  
b) Construct a circuit to convert four bit serial data to parallel data and explain its working. (7)
12. a) Realize a 16:1 multiplexer using four bit multiplexers and basic gates. Also explain it using its switching expression (8)  
b) Explain the working of JK flip flop with its circuit and truth table. (6)

**Module II**

13. a) Draw VI characteristics of n-channel MOSFET and explain it with the current equation (8)  
b) Draw the circuit diagram of a two input CMOS NAND gate (6)
14. a) Draw the stick diagram and Layout of a CMOS inverter (8)  
b) Explain any 5 Lambda based design rules (6)

**Module III**

15. a) Explain the Pre charge- Evaluate phase in the dynamic logic. (6)  
b) Draw a 4x4 MOS ROM Cell Array and explain its working (8)
16. a) With neat schematic diagram, explain the working of NP domino logic. What is its advantage over domino logic? (8)  
b) Explain the working of a three transistor DRAM cell (6)

**Module IV**

17. a) What is FPGA? What are its applications? With block diagram explain its internal architecture? (7)  
b) Explain ASIC design flow. (7)
18. a) Explain the Top-Down and Bottom-Up design approaches in FPGA based system designs (7)  
b) List the advantages of SOC (7)

**Module V**

19. a) Explain the gate array based ASICs with neat diagram (7)  
b) With necessary diagram illustrate antifuse technique used in programmable ASICs (7)
20. a) Discuss the different types of I/O cells that are used in programmable ASICs and their functions (6)  
b) Define setup time, hold time, propagation delay and clock to output delay. (8)

| B24ECM62 | DATA NETWORKS (Minor) | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|----------|-----------------------|---|---|---|---|--------|----------------------|
|          |                       | 3 | 1 | 0 | 5 | 4      | 2024                 |

### Preamble

The course aims to expose students to computer networks taking a top-down approach of viewing from the layer of user applications and zooming into link layer protocols. The principles of various protocols used in every layer are studied in detail.

### Prerequisites

B24EC3T03 : ANALOG AND DIGITAL COMMUNICATION

### Course Outcomes

After the completion of the course, the student will be able to:

|             |                                                                                                                                                    |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the fundamental concepts, components, and technologies in computer networks.[Understand]                                                |
| <b>CO 2</b> | Analyze and evaluate different network topologies, transmission media, and communication protocols used across networking layers. [Analyze, Apply] |
| <b>CO 3</b> | Describe and differentiate the layers of the OSI and TCP/IP models with respect to their functions and applications.[Understand]                   |
| <b>CO 4</b> | Design and implement basic network configurations and protocols for reliable data communication [Analyze,Apply]                                    |
| <b>CO 5</b> | Analyze and apply routing, addressing, and Quality of Service (QoS) mechanisms for efficient network performance. [Analyze,Apply]                  |

### Mapping of Course Outcomes With Program Outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 3    | 3    |      |      |      |      |      | 1    |       | 2     |
| <b>CO 2</b> | 3    | 3    | 3    |      | 1    |      | 2    |      | 1    |       | 2     |
| <b>CO 3</b> | 3    | 3    | 3    |      |      |      |      |      | 1    |       | 2     |
| <b>CO 4</b> | 3    | 3    | 3    |      | 1    |      | 2    |      | 1    |       | 2     |
| <b>CO 5</b> | 3    | 3    | 3    |      | 1    |      | 2    |      | 1    |       | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 30                    | 30                 | 30                                    |
| Apply            | 50                    | 50                 | 50                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.



## SYLLABUS

### MODULE 1

**Introduction to Computer Networks:** Introduction to Computer Networks – Overview, Applications of Networks, The Internet – History, Evolution, Protocols, and Standards, Network Models – OSI Reference Model: Layers and Functions. TCP/IP Reference Model – Comparison with OSI Model. Addressing in Networks – Types of Addresses (Physical, Logical, Port, Specific), Switching Techniques – Circuit Switching and Packet Switching, Network Topologies – Types and Applications, Physical Layer – Transmission Media: Guided Media (Twisted Pair, Coaxial, Optical Fiber), Wireless Media, Digital Modulation (Baseband and Passband), Multiplexing (FDM, TDM).

### MODULE 2

**The data link layer:** Functions of Data Link Layer – Overview, Error Detection and Correction – Linear Block Codes, Cyclic Redundancy Check (CRC) – Concept and Example, Framing Methods – Character and Bit Stuffing, Flow Control and Error Control – Stop-and-Wait, ARQ Mechanisms, Data Link Protocols – HDLC and its Operation, Multiple Access Protocols – Random Access (ALOHA, CSMA), Controlled Access, Reservation, Polling, Token Passing, LAN Standards – Ethernet, WLAN (IEEE 802.11), Devices: Hubs, Bridges, Switches.

### MODULE 3

**Network layer:** Functions of the Network Layer – Overview, Packet Switching Networks – Principles and Operation, Routing Concepts – Static vs Dynamic, Routing Tables, Shortest Path Routing – Dijkstra's Algorithm, Link State Routing and Distance Vector Routing, IPv4 Protocol – Header Format and Functions, IPv4 Addressing – Classes, Subnetting, Supernetting, Transition to IPv6 – Features and Differences, Network Devices – Routers and Gateways, NAT (Network Address Translation).

### MODULE 4

**Transport Layer:** Transport Layer Overview – Services and Responsibilities, User Datagram Protocol (UDP) – Header and Features, Transmission Control Protocol (TCP) – Features, Connection Establishment, Flow Control, Error Control and Congestion Controls, Application Layer Overview – Functions, WWW and HTTP – Structure and Operation, Domain Name System (DNS) – Name Resolution Process, Network Security Basics – Goals, Types of Attacks, Cryptographic Techniques – Symmetric (DES, AES), Public Key (RSA), Firewall, SSL.

## **MODULE 5**

**QoS for Networking:** Definition, Parameters (Delay, Jitter, Throughput, Loss), QoS Issues in Networks – Need for QoS in Modern Applications, Broadband Services – DSL, Cable Modem, Fiber Broad Band, QoS Mechanisms – Classification and Scheduling, Queuing Disciplines – FIFO, Priority Queuing, Weighted Fair Queuing, Weighted Fair Queuing (WFQ) – Concept, Operation, and Example, Traffic Shaping and Policing – Leaky Bucket, Token Bucket, Integrated and Differentiated Services in QoS

**Case Study:** Implementing QoS in a Corporate VoIP Network

### **Text Books**

1. Behrouz A. Fourouzan, Data Communications and Networking, Tata McGraw Hill, 2/e.
2. Andrew S. Tanenbaum, Computer Networks, Pearson education/ PHI Ltd., 4/e .
3. James F. Kurose and Keith W. Ross, Computer Networking - A Top-Down Approach Featuring the Internet, Pearson Education, 2/e .
4. Bertsekas and Gallagar, Data Networks, Prentice Hall India, 2/e.
5. F. Halsall, Data Communication, Computer Networks and Open Systems, Addison Wesley, 1996.
6. D. Bertsekas, R. Gallager, Data Networks, Prentice Hall.
7. Larry L. Peterson, Bruce S. Davie, Computer Networks – A Systems Approach, Morgan Kaufman

**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                              | <b>No of Lecture/Tutorial Hours</b> |
|-----------|-------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                           | <b>9</b>                            |
| 1.1       | Introduction to Computer Networks – Overview, Applications of Networks.                   | 1                                   |
| 1.2       | The Internet – History, Evolution, Protocols, and Standards                               | 1                                   |
| 1.3       | Network Models – OSI Reference Model: Layers and Functions.                               | 1                                   |
| 1.4       | TCP/IP Reference Model – Comparison with OSI Model.                                       | 1                                   |
| 1.5       | Addressing in Networks – Types of Addresses (Physical, Logical, Port, Specific).          | 1                                   |
| 1.6       | Switching Techniques – Circuit Switching and Packet Switching                             | 1                                   |
| 1.7       | Network Topologies – Types and Applications.                                              | 1                                   |
| 1.8       | Physical Layer – Transmission Media: Guided Media (Twisted Pair, Coaxial, Optical Fiber). | 1                                   |
| 1.9       | Wireless Media, Digital Modulation (Baseband and Pass-band), Multiplexing (FDM, TDM).     | 1                                   |
|           | <b>Module 2</b>                                                                           | <b>9</b>                            |
| 2.1       | Functions of Data Link Layer – Overview.                                                  | 1                                   |
| 2.2       | Error Detection and Correction – Linear Block Codes.                                      | 1                                   |
| 2.3       | Cyclic Redundancy Check (CRC) – Concept and Example.                                      | 1                                   |
| 2.4       | Framing Methods – Character and Bit Stuffing.                                             | 1                                   |
| 2.5       | Flow Control and Error Control – Stop-and-Wait, ARQ Mechanisms.                           | 4                                   |
| 2.6       | Data Link Protocols – HDLC and its Operation.                                             | 1                                   |
| 2.7       | Multiple Access Protocols – Random Access (ALOHA, CSMA).                                  | 1                                   |
| 2.8       | Controlled Access – Reservation, Polling, Token Passing.                                  | 1                                   |
| 2.9       | LAN Standards – Ethernet, WLAN (IEEE 802.11), Devices: Hubs, Bridges, Switches.           | 1                                   |
|           | <b>Module 3</b>                                                                           | <b>9</b>                            |
| 3.1       | Functions of the Network Layer – Overview                                                 | 1                                   |
| 3.2       | Packet Switching Networks – Principles and Operation.                                     | 1                                   |
| 3.3       | Routing Concepts – Static vs Dynamic, Routing Tables                                      | 1                                   |
| 3.4       | Shortest Path Routing – Dijkstra's Algorithm.                                             | 1                                   |
| 3.5       | Link State Routing and Distance Vector Routing                                            | 1                                   |
| 3.6       | IPv4 Protocol – Header Format and Functions.                                              | 1                                   |
| 3.7       | IPv4 Addressing – Classes, Subnetting, Supernetting.                                      | 1                                   |
| 3.8       | Transition to IPv6 – Features and Differences.                                            | 1                                   |

|     |                                                                                   |                 |
|-----|-----------------------------------------------------------------------------------|-----------------|
| 3.9 | Network Devices – Routers and Gateways, NAT (Network Address Translation).        | 1               |
|     | <b>Module 4</b>                                                                   | <b>9</b>        |
| 4.1 | Transport Layer Overview – Services and Responsibilities.                         | 1               |
| 4.2 | User Datagram Protocol (UDP) – Header and Features                                | 1               |
| 4.3 | Transmission Control Protocol (TCP) – Features, Connection Establishment.         | 1               |
| 4.4 | TCP Flow Control, Error Control, and Congestion Control.                          | 1               |
| 4.5 | FSM: Application Layer Overview – Functions.                                      | 1               |
| 4.6 | WWW and HTTP – Structure and Operation.                                           | 1               |
| 4.7 | Domain Name System (DNS) – Name Resolution Process.                               | 1               |
| 4.8 | Network Security Basics – Goals, Types of Attacks.                                | 1               |
| 4.9 | Cryptographic Techniques – Symmetric (DES, AES), Public Key (RSA), Firewall, SSL. | 1               |
|     | <b>Module 5</b>                                                                   | <b>9</b>        |
| 5.1 | Introduction to QoS – Definition, Parameters (Delay, Jitter, Throughput, Loss)    | 1               |
| 5.2 | QoS Issues in Networks , Need for QoS in Modern Applications.                     | 1               |
| 5.3 | Broadband Services – DSL, Cable Modem, Fiber Broadband.                           | 1               |
| 5.4 | QoS Mechanisms – Classification and Scheduling                                    | 1               |
| 5.5 | Queuing Disciplines – FIFO, Priority Queuing.                                     | 1               |
| 5.6 | Weighted Fair Queuing (WFQ) – Concept, Operation, and Example.                    | 1               |
| 5.7 | Traffic Shaping and Policing – Leaky Bucket, Token Bucket.                        | 1               |
| 5.8 | Integrated and Differentiated Services in QoS                                     | 1               |
| 5.9 | Case Study: Implementing QoS in a Corporate VoIP Network.                         | 1               |
|     | <b>Total Hours</b>                                                                | <b>45 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Define and differentiate between circuit switching and packet switching.
2. Explain the main functions of each layer in the OSI reference model.
3. List and describe different types of network topologies with examples.

**Course Outcome 2 (CO 2):**

1. What is the purpose of error detection and how is CRC used for it?
2. Compare ALOHA and CSMA multiple access techniques.
3. Explain the difference between a hub, bridge, and switch in LANs.

**Course Outcome 3 (CO 3):**

1. Describe the working of the shortest path routing algorithm.
2. What is the difference between IPv4 and IPv6 addressing?
3. Explain the role of Network Address Translation (NAT) in communication.

**Course Outcome 4 (CO 4):**

1. Differentiate between TCP and UDP with suitable examples.
2. Explain the function of DNS in the Internet.
3. What is the difference between symmetric and asymmetric encryption?

**Course Outcome 5 (CO 5):**

1. Define Quality of Service and explain its importance in modern networks.
2. What are the main QoS parameters — delay, jitter, and packet loss?
3. Describe the concept and working of Weighted Fair Queuing (WFQ).

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 2**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24ECM62**

**Course Name: DATA NETWORKS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Compare the OSI and TCP/IP reference models.
2. Differentiate between circuit switching and packet switching.
3. Explain error detection using Cyclic Redundancy Check (CRC).
4. What is the difference between ALOHA and CSMA multiple access methods?
5. Explain the working of the shortest path routing algorithm.
6. What is Network Address Translation (NAT) and why is it used?
7. Differentiate between TCP and UDP protocols.
8. What is the difference between symmetric key and public key encryption?
9. Define Quality of Service (QoS) and its need in networks.
10. Explain the purpose of queuing disciplines.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**



11. a) Explain the TCP/IP model in detail. (7)  
b) Discuss different types of transmission media. Compare guided and unguided media. (7)
12. a) Describe and compare packet switching and circuit switching with neat diagrams. (7)  
b) Explain digital modulation techniques and multiplexing methods (FDM and TDM) used in data transmission. (7)

**Module II**

13. a) Explain Error Correction techniques using Linear Block Codes and CRC with examples.. (7)  
b) Describe ARQ protocols. Compare Stop-and-Wait ARQ and Sliding Window ARQ. (7)
14. a) Explain multiple access techniques – ALOHA, CSMA, and Token Passing methods. (7)  
b) Discuss the IEEE 802.3 Ethernet and IEEE 802.11 WLAN standards and list their main features. (7)

**Module III**

15. a) Explain various routing algorithms. Compare link-state and distance-vector routing. (7)  
b) Explain IPv4 addressing . (7)
16. a) Describe the transition from IPv4 to IPv6. How does NAT help in address conservation? (7)  
b) Explain the working principles of routers and gateways with neat diagrams. (7)

**Module IV**

17. a) Compare the features and services provided by TCP and UDP. (7)  
b) Explain the architecture and working of HTTP protocol. (7)
18. a) Explain symmetric key encryption algorithms (7)  
b) Explain public key encryption using RSA and discuss the role of Firewalls and SSL in network security.. (7)

**Module V**

19. a) Define Quality of Service (QoS). Explain the key QoS parameters affecting network performance. (7)  
b) Discuss different broadband technologies and their QoS requirements (7)
20. a) Explain various queuing disciplines used for QoS management. (7)  
b) Describe Weighted Fair Queuing (WFQ) and explain how it ensures fair bandwidth allocation.s (7)

| B24ECM63 | INTRODUCTION<br>TO COMPUTER<br>VISION<br>(Minor) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|----------|--------------------------------------------------|---|---|---|---|--------|-------------------------|
|          |                                                  | 3 | 1 | 0 | 5 |        |                         |

### Preamble

This course aims to develop the knowledge of various methods, algorithms and applications of computer vision .

### Prerequisites

B24ECM33 : INTRODUCTION TO SIGNALS AND SYSTEMS

B24ECM43 : INTRODUCTION TO DIGITAL SIGNAL PROCESSING

B24ECM53 : INTRODUCTION TO DIGITAL IMAGE PROCESSING

### Course Outcomes

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                            |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Apply basic point operators and 2D transforms for digital filtering operations. [Understand,Apply]                                                                         |
| <b>CO 2</b> | Apply various algorithms for morphological operations and binary shape analysis. [Understand, Apply]                                                                       |
| <b>CO 3</b> | Understand the theoretical aspects of image formation and 3D camera models and vision system.[Understand, Apply]                                                           |
| <b>CO 4</b> | Apply edge, corner detection methods and optical flow algorithms to locate objects in an image/video. [Understand, Apply]                                                  |
| <b>CO 5</b> | Analyse 3D images and motion of objects in a given scene using appropriate algorithms computer vision algorithms for real time practical applications. [Understand, Apply] |

### Mapping of Course Outcomes With Program Outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 3    | 3    | 3    | 3    | 1    | 1    | 1    | 1    | 1     | 2     |
| <b>CO 2</b> | 3    | 3    | 3    | 3    | 3    | 1    | 1    | 1    | 1    | 1     | 2     |
| <b>CO 3</b> | 3    | 3    | 3    | 3    | 3    | 1    | 1    | 1    | 1    | 1     | 2     |
| <b>CO 4</b> | 3    | 3    | 3    | 3    | 3    | 1    | 1    | 1    | 1    | 1     | 2     |
| <b>CO 5</b> | 3    | 3    | 3    | 3    | 3    | 1    | 1    | 1    | 1    | 1     | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 40                    | 40                 | 40                                    |
| Apply            | 40                    | 40                 | 40                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

## SYLLABUS

### MODULE 1

**Review of image processing techniques:** Filtering, Point operators-Histogram Based operators, neighbourhood operators, Thresholding - linear filtering – development of filtering masks - 2D Fourier transforms – filtering in frequency domain, Homomorphic filtering

### MODULE 2

**Mathematical Operators:** Binary shape analysis: Basics of Morphological operations, structuring element, Erosion, Dilation, Opening and Closing, Hit-or-Miss Transform, Connectedness, object labelling and counting, Boundary descriptors – Chain codes.

### MODULE 3

**Camera models:** Monocular and binocular imaging system, Orthographic and Perspective Projection, Image formation, geometric transformations, Camera Models (Basic idea only), 3D-Imaging system-Stereo Vision.

### MODULE 4

**Feature Detection:** Edge detection – edges, lines, active contours, Split and merge, Mean shift and mode finding, Normalized cuts, Graph cuts, energy-based and Canny's methods. Corner detection, Harris corner detection algorithm, Line and curve detection, Hough transform SIFT operators, Shape from X, Shape Matching, Structure from motion.

### MODULE 5

**Motion Analysis:** Regularization theory, Optical Flow: brightness constancy equation, aperture problem, Horn-Shunck method, Lucas-Kanade method. (Analysis not required) Object Detection and Object classification: SVM, Linear discriminant analysis, Bayes rule, ML. Face detection, Face Recognition, Eigen faces, 3D face models Applications of Computer Vision: Context and scene understanding, Real Time applications: Locating road way and road marking, locating road signs and pedestrians.

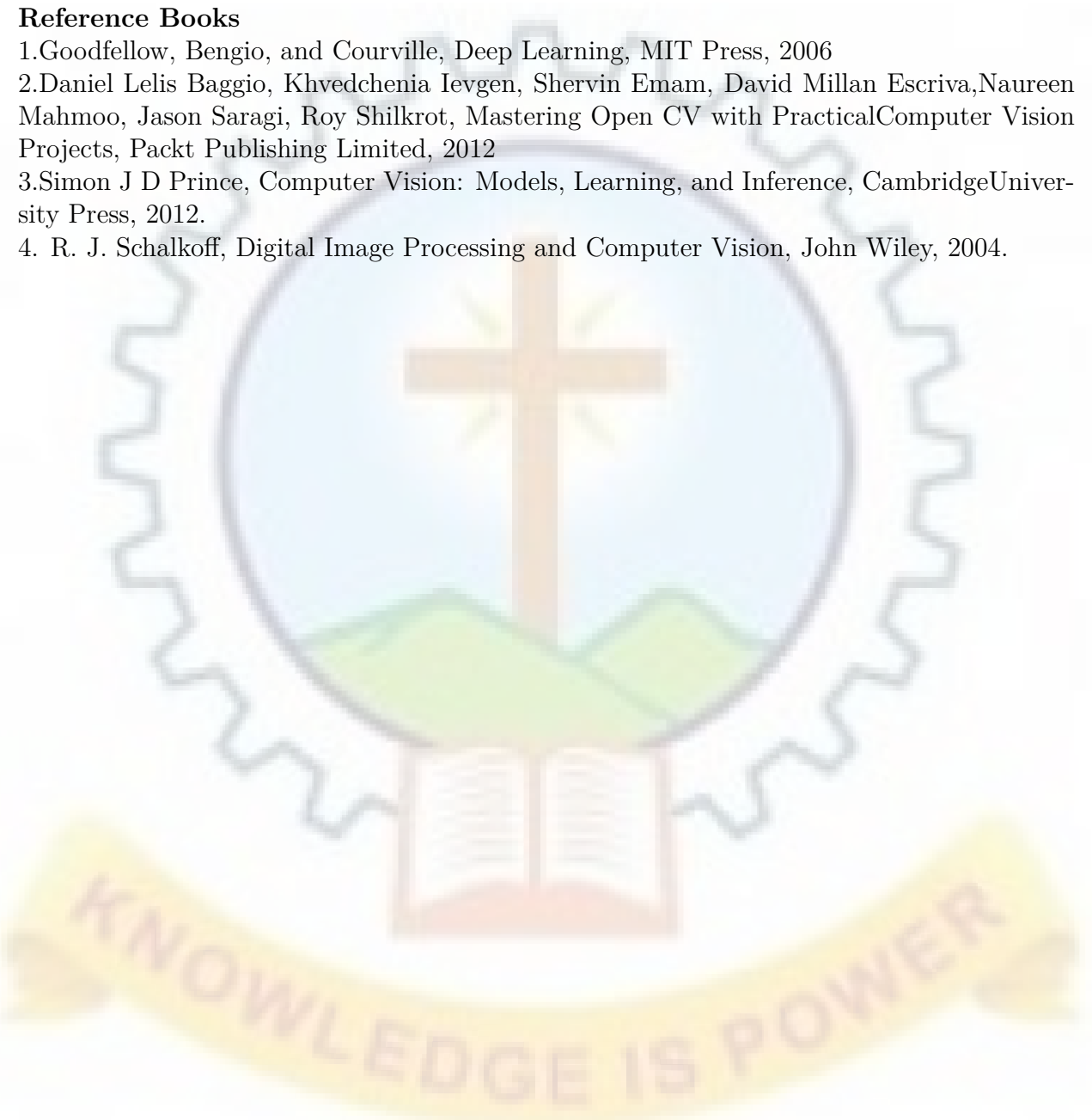
### Text Books

1.E. R .Davies, Computer and Machine Vision -Theory Algorithm and Practicalities, Academic Press, 2012

2. Richard Szeliski, Computer Vision: Algorithms and Applications, ISBN 978-1-84882-935-0, Springer 2011
3. David Forsyth and Jean Ponce, Computer Vision: A Modern Approach, Pearson India, 2002.

### **Reference Books**

1. Goodfellow, Bengio, and Courville, Deep Learning, MIT Press, 2006
2. Daniel Lelis Baggio, Khvedchenia Ievgen, Shervin Emam, David Millan Escrivá, Naureen Mahmood, Jason Saragi, Roy Shilkrot, Mastering Open CV with Practical Computer Vision Projects, Packt Publishing Limited, 2012
3. Simon J D Prince, Computer Vision: Models, Learning, and Inference, Cambridge University Press, 2012.
4. R. J. Schalkoff, Digital Image Processing and Computer Vision, John Wiley, 2004.



**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                                                                                    | <b>No of Lecture/Tutorial Hours</b> |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                                                                                                 | <b>8</b>                            |
| 1.1       | Review of image processing techniques: filtering.                                                                                                                               | 2                                   |
| 1.2       | Point operators- Histogram, neighbourhood operators, thresholding- development of filtering masks.                                                                              | 3                                   |
| 1.3       | 2D Fourier transforms – filtering in frequency domain, homomorphic filtering.                                                                                                   | 3                                   |
|           | <b>Module 2</b>                                                                                                                                                                 | <b>8</b>                            |
| 2.1       | Mathematical Operators: Basics of Morphological operations, structuring element.                                                                                                | 2                                   |
| 2.2       | Binary shape analysis : Erosion, Dilation, Opening and Closing, Hit-or-Miss Transform.                                                                                          | 2                                   |
| 2.3       | Connectedness, object labelling and counting.                                                                                                                                   | 2                                   |
| 2.4       | Boundary descriptors –Chain Codes.                                                                                                                                              | 2                                   |
|           | <b>Module 3</b>                                                                                                                                                                 | <b>9</b>                            |
| 3.1       | Camera models: Monocular and binocular imaging system.                                                                                                                          | 2                                   |
| 3.2       | Orthographic Perspective Projection.                                                                                                                                            | 2                                   |
| 3.3       | Image formation, geometric transformations, camera Models(Basic idea only).                                                                                                     | 3                                   |
| 3.4       | 3D-Imaging system-Stereo Vision.                                                                                                                                                | 2                                   |
|           | <b>Module 4</b>                                                                                                                                                                 | <b>10</b>                           |
| 4.1       | Feature Detection: Edge detection – edges, lines, active contours, Split and merge, Mean shift and mode finding, Normalized cuts, Graph cuts, energy-based and Canny's methods. | 4                                   |
| 4.2       | Corner detection, Harris corner detection algorithm, Line and curve detection, Hough transform.                                                                                 | 3                                   |
| 4.3       | SIFT operators, Shape from X, Shape Matching.                                                                                                                                   | 3                                   |
|           | <b>Module 5</b>                                                                                                                                                                 | <b>10</b>                           |
| 5.1       | Motion Analysis- Regularization theory, Optical Flow: brightness constancy equation, aperture problem, Horn-Shunck method, Lucas-Kanade method (Analysis not required).         | 3                                   |
| 5.2       | Object Detection and Object classification: SVM, Linear discriminant analysis, Bayes rule, maximum likelihood, Face detection, Face Recognition, Eigen faces, 3D face models.   | 4                                   |
| 5.3       | Applications of Computer Vision: Context and scene understanding, Real Time applications: Locating road way and road marking, locating road signs and pedestrians.              | 3                                   |
|           | <b>Total Hours</b>                                                                                                                                                              | <b>45 Hours</b>                     |



## CO ASSESSMENT QUESTIONS

### Course Outcome 1 (CO 1):

1. Why histogram transformations are applied in a grey scale image and what output is observed in that case.
2. Find filtered image using LP/HP/Smoothing/Median filter.
3. Describe the working principle of Homomorphic filter.

### Course Outcome 2 (CO 2):

1. List different morphological operators and describe about each one in detail.
2. To describe connected component labelling and to apply it in a given image pixel set.
3. Find 8-point connectivity and Chain code of a given image pixel diagram..

### Course Outcome 3 (CO 3):

1. Differentiate between Monocular and binocular imaging system.
2. Compare and Contrast Orthographic and Perspective Projection methods.
3. Describe image formation and geometric transformations in 3D Camera Models
4. Write short notes on 3D-Imaging system.
5. Briefly describe a stereo vision system.

### Course Outcome 4 (CO 4):

1. What is the role of edge detection and corner detection in Computer Vision applications?.
2. .Describe Canny's edge detection algorithm.
3. .Mention the steps in Harris corner detection algorithm and explain how it is employed to detect corners in an image.
4. State with necessary mathematical steps, how Hough transform is employed for detecting lines and curves in detecting an image.

**Course Outcome 5 (CO 5):**

1. Analyse a given video to track a moving object in it.
2. To detect a particular object from the background.
3. To detect signboards/ pedestrian crossings/pedestrians from a moving vehicle.
4. To classify/segment a particular set of image using CV algorithms.
5. Analyse a given image/video using Machine learning/Deep learning algorithms.
6. Use trained networks to analyse a video using ML algorithms.
7. To use Deep neural networks/CNN/YOLOvx, to analyse images/videos.
8. Find Eigen values and Eigen Vectors of a matrix

MODEL QUESTION PAPER

QP CODE:

Pages: 5

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027

Course Code: B24ECM63

Course Name: INTRODUCTION TO COMPUTER VISION

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks

1. Compare and Contrast DoG and LoG?
2. An image is convolved with the matrix given below. Express analytically the relation between original and modified image.

|    |    |    |
|----|----|----|
| •0 | •0 | •0 |
| •0 | •0 | •1 |
| •0 | •0 | •0 |

3. List any three computer vision applications of object labeling and counting?
4. Describe steps in identifying connected components in 4-connectivity and 8-connectivity cases.
5. Describe the working principle of pin- hole camera?
6. Compare and contrast perspective and orthographic projection
7. Mention the concept of identifying structure from motion.

8. Illustrate how graph cut method is employed for edge detection
9. Define eigen values and eigen vectors.
10. Differentiate between SVM and LDA.

### PART B

**Answer any one question from each module. Each question carries 14 marks**

#### Module I

11. a) What is thresholding? Briefly describe different methods of thresholding. (6)  
b) Apply 2D-DFT on the given image pixel values. (8)

$$\begin{bmatrix} 1 & 2 & 2 & 0 \\ 0 & 1 & 3 & 1 \\ 0 & 1 & 2 & 1 \\ 1 & 2 & 2 & 1 \end{bmatrix}$$

12. a) Describe how histogram transformations are applied on a grey scale image and explain what output is observed in each case. (8)  
b) Describe the working principle of Homomorphic filter, with different mathematical steps involved. (6)

#### Module II

13. a) An image A, and a structuring element B are given. Apply B on A, to find resultant images after the dilation and erosion process. Origin is given as 'O'; and note that it is not part of the structuring element. (8)

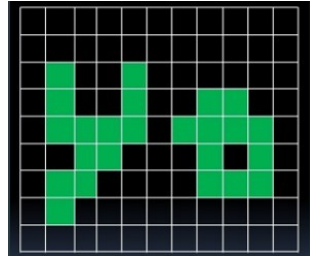
A =

|   |   |   |   |   |   |
|---|---|---|---|---|---|
|   |   |   |   |   |   |
|   | 1 | 1 | 1 |   |   |
|   | 1 |   | 1 |   |   |
|   | 1 |   | 1 | 1 |   |
|   |   |   |   | 1 | 1 |
| O |   |   |   |   |   |

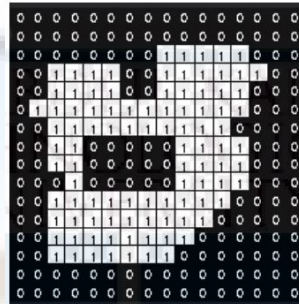
B =

|   |   |   |
|---|---|---|
| 1 | O | 1 |
|---|---|---|

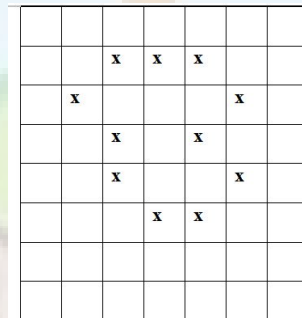
- b) Using Hoshen–Kopelman algorithm, assign connected component labelling for the given image in the diagram above. (6)



14. a) Apply Hit-or-Miss transform on the given binary image to detect right angle convex corners from left-top to right-bottom. (8)



- b) For the given image grid, find out the 8-chain Freeman Code. Also write down the chain number of the code. (6)



### Module III

15. Describe image formation and geometric transformations in 3D Camera Models. (14)
16. a) Briefly describe a stereo vision system. (7)
- b) Elucidate on 3D-Imaging Camera system. (7)

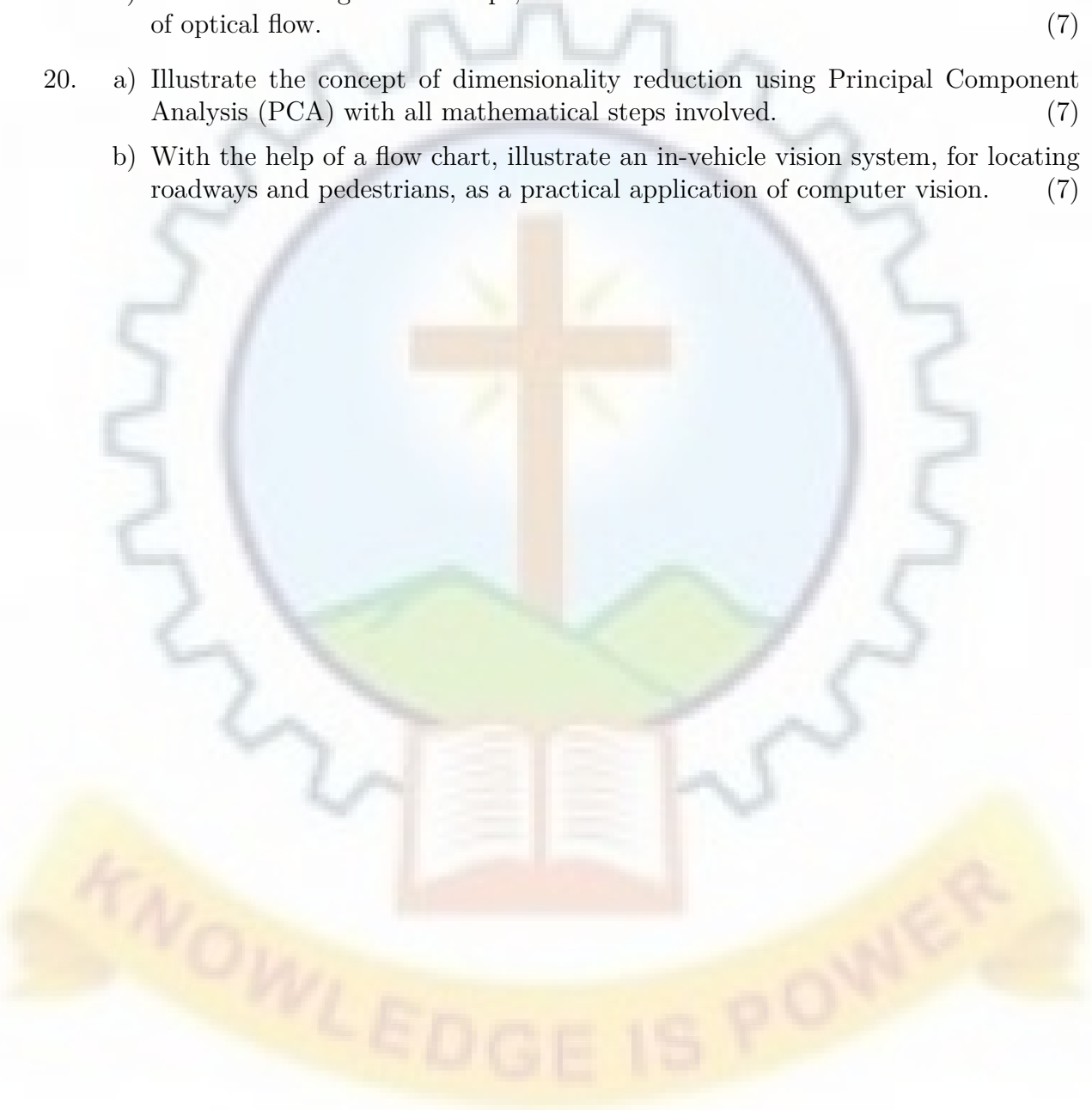
### Module IV

17. a) With the help of a general algorithm, narrate how Hough Transform can be employed for interest point detection. (7)
- b) Unveil different steps involved in Harris corner detection algorithm and explain how it is employed to detect corners in an image. (7)
18. a) Apply Sobel and Prewitt masks on the given image grids and compute  $G_x$  and  $G_y$  gradients of the images.. (7)

- b) Referring to Canny's algorithm, describe how it is employed to detect edges of an image. (7)

**Module V**

19. a) Derive brightness constancy equation. (7)  
b) Describe with algorithmic steps, the Horn-Shunk method used for the estimation of optical flow. (7)
20. a) Illustrate the concept of dimensionality reduction using Principal Component Analysis (PCA) with all mathematical steps involved. (7)  
b) With the help of a flow chart, illustrate an in-vehicle vision system, for locating roadways and pedestrians, as a practical application of computer vision. (7)





| <b>B24ECH61</b> | <b>ELECTRONIC<br/>DESIGN AND<br/>AUTOMATION<br/>TOOLS<br/>(Honours)</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF<br/>INTRODUCTION</b> |
|-----------------|-------------------------------------------------------------------------|----------|----------|----------|----------|---------------|---------------------------------|
|                 |                                                                         | 3        | 1        | 0        | 5        |               |                                 |

**Preamble**

The course aims to introduce principles behind advanced methods in automation of electronic design.

**Prerequisites**

Nil

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                              |
|-------------|--------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Apply Search Algorithms and Shortest Path Algorithms to find various graph solutions.                        |
| <b>CO 2</b> | Outline VLSI Design Flow and Design Styles and apply partitioning algorithms on graphs representing netlist. |
| <b>CO 3</b> | Illustrate Design Layout Rules and apply different algorithms for layout compaction.                         |
| <b>CO 4</b> | Make use of various algorithms to solve placement and floorplan problems.                                    |
| <b>CO 5</b> | Utilise different algorithms to solve routing problems.                                                      |

**Mapping of Course Outcomes With Program Outcomes**

|             | <b>PO 1</b> | <b>PO 2</b> | <b>PO 3</b> | <b>PO 4</b> | <b>PO 5</b> | <b>PO 6</b> | <b>PO 7</b> | <b>PO 8</b> | <b>PO 9</b> | <b>PO 10</b> | <b>PO 11</b> |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|
| <b>CO 1</b> | 3           | 2           |             |             |             |             |             |             |             |              | 3            |
| <b>CO 2</b> | 3           | 2           |             |             |             |             |             |             |             |              | 3            |
| <b>CO 3</b> | 3           | 2           |             |             |             |             |             |             |             |              | 3            |
| <b>CO 4</b> | 3           | 2           |             |             |             |             |             |             |             |              | 3            |
| <b>CO 5</b> | 3           | 2           |             |             |             |             |             |             |             |              | 3            |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         |                       |                    |                                       |
| Understand       | 30                    | 30                 | 60                                    |
| Apply            | 20                    | 20                 | 40                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Quiz/Course project         | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

#### **Graph Terminology, Search Algorithms and Shortest Path Algorithms:**

**Graph Terminology:** Basic graph theory terminology, Data structures for representation of Graphs.

**Search Algorithms:** Breadth First Search, Depth First Search, Topological Sort.

**Shortest Path Algorithms:** Dijkstra's Shortest-Path Algorithm for single pair shortest path, Floyd Warshall Algorithm for all pair shortest path.

### MODULE 2

#### **Design Automation and Partitioning Algorithms:**

**Design Automation:** VLSI Design Flow, VLSI Design Styles.

**Partitioning:** Levels of Partitioning, Parameters for Partitioning, Classification of Partitioning Algorithms, Kernighan-Lin Algorithm, Fiduccia-Mattheyses Algorithm, Simulated Annealing.

### MODULE 3

#### **Layout Compaction:**

**Layout:** Layout Layers and Design Rules, Physical Design Optimizations.

**Compaction:** Applications of Compaction, Informal Problem Formulation, Graph Theoretical Formulation, Maximum Distance Constraints, Longest Path algorithm for DAG, Longest path in graph with cycles, Liao-Wong Algorithm, Bellman-Ford Algorithm.

### MODULE 4

#### **Placement and Floorplanning:**

**Placement:** Optimization Objectives, Wirelength Estimation, Weighted Wirelength, Maximum Cut Size, Wire Density.

**Placement Algorithms:** Quadratic Placement.

**Floorplanning:** Optimization Objectives, Slicing Floorplan, Non-Slicing Floorplan.

**Floorplan Representations:** Constraint Graph, Sequence Pair.

**Floorplan Algorithms:** Minimum Area Algorithm.

## MODULE 5

### **Global Routing and Detailed Routing:**

**Global Routing:** Terminology and Definitions, Optimization Goals, Representation of Routing Regions.

**Maze Routing Algorithms:** Lee's Algorithm, Hadlock Algorithm.

**Detailed Routing:** Horizontal and Vertical Constraint Graph.

**Channel Routing Algorithms:** Left-Edge algorithm.

### **Text Books**

1. Jin Hu, Jens Lienig, Igor L. Markov, Andrew B. Kahng, VLSI Physical Design: From Graph Partitioning to Timing Closure, Springer, 2011th edition.
2. Gerez, Sabih H., "Algorithms for VLSI Design Automation", John Wiley & Sons, 2006.
3. Sherwani, Naveed A., "Algorithms for VLSI Physical Design Automation", Kluwer Academic Publishers, 1999.
4. Sadiq M. Sait and H. Youssef, "VLSI Physical Design Automation: Theory and Practice", World Scientific, 1999.
5. Cormen, Thomas H., Charles E. Leiserson, and Ronald L. Rivest. "Introduction to Algorithms." The MIT Press, 3rd edition, 2009.

## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                        | No of Lecture/Tutorial Hours |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                              | <b>8</b>                     |
| 1.1 | <b>Graph Terminology:</b> Basic graph theory terminology, Data structures for representation of Graphs.                                                      | 2                            |
| 1.2 | <b>Search Algorithms:</b> Breadth First Search, Depth First Search, Topological Sort.                                                                        | 2                            |
| 1.3 | <b>Shortest Path Algorithms:</b> Dijkstra's Shortest-Path Algorithm for single pair shortest path, Floyd Warshall Algorithm for all pair shortest path.      | 4                            |
|     | <b>Module 2</b>                                                                                                                                              | <b>9</b>                     |
| 2.1 | <b>Design Automation:</b> VLSI Design Flow, VLSI Design Styles.                                                                                              | 3                            |
| 2.2 | <b>Partitioning:</b> Levels of Partitioning, Parameters for Partitioning, Classification of Partitioning Algorithms.                                         | 1                            |
| 2.3 | Kernighan-Lin Algorithm, Fiduccia-Mattheyses Algorithm, Simulated Annealing.                                                                                 | 5                            |
|     | <b>Module 3</b>                                                                                                                                              | <b>9</b>                     |
| 3.1 | <b>Layout:</b> Layout Layers and Design Rules, Physical Design Optimizations.                                                                                | 1                            |
| 3.2 | <b>Compaction:</b> Applications of Compaction, Informal Problem Formulation, Graph Theoretical Formulation, Maximum Distance Constraints.                    | 1                            |
| 3.3 | Longest Path algorithm for DAG, Longest path in graph with cycles, Liao-Wong Algorithm, Bellman-Ford Algorithm..                                             | 7                            |
|     | <b>Module 4</b>                                                                                                                                              | <b>11</b>                    |
| 4.1 | <b>Placement:</b> Optimization Objectives, Wirelength Estimation, Weighted Wirelength, Maximum Cut Size, Wire Density.                                       | 3                            |
| 4.2 | <b>Placement Algorithms:</b> Quadratic Placement.                                                                                                            | 2                            |
| 4.3 | <b>Floorplanning:</b> Optimization Objectives, Slicing Floorplan, Non- Slicing Floorplan. <b>Floorplan Representations:</b> Constraint Graph, Sequence Pair. | 3                            |
| 4.4 | <b>Floorplan Algorithms:</b> Minimum Area Algorithm.                                                                                                         | 3                            |
|     | <b>Module 5</b>                                                                                                                                              | <b>8</b>                     |
| 5.1 | <b>Global Routing:</b> Terminology and Definitions, Optimization Goals, Representation of Routing Regions.                                                   | 1                            |
| 5.2 | <b>Maze Routing Algorithms:</b> Lee's Algorithm, Hadlock Algorithm.                                                                                          | 2                            |
| 5.3 | <b>Detailed Routing:</b> Horizontal and Vertical Constraint Graph.                                                                                           | 3                            |
| 5.4 | <b>Channel Routing Algorithms:</b> Left-Edge algorithm.                                                                                                      | 2                            |

|  |                    |                 |
|--|--------------------|-----------------|
|  | <b>Total Hours</b> | <b>45 Hours</b> |
|--|--------------------|-----------------|

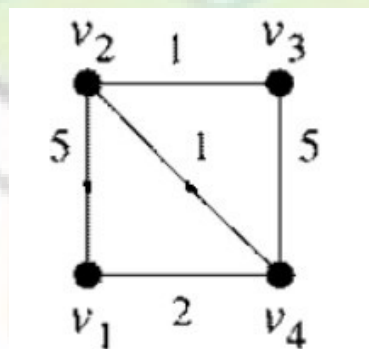
### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Represent the following graph by Adjacency Matrix.
2. List a DFS ordering of vertices for the graph shown in question 1 with starting node as H.
3. Perform topological sort on the graph in question1 and order the vertices with Starting node is H.

#### Course Outcome 2 (CO 2):

1. Perform KL partitioning on the below graph. You may assume any initial partition of your choice.

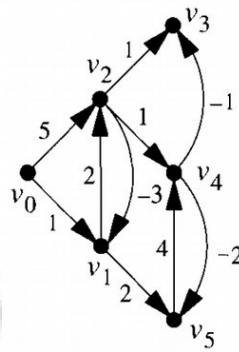


2. Draw the flowchart of VLSI Design Flow and explain the different stages.

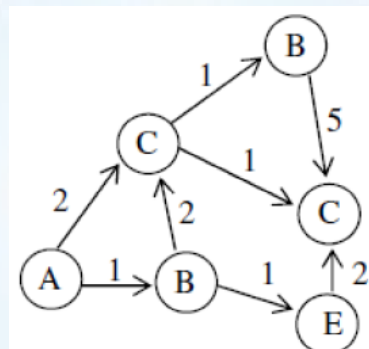
#### Course Outcome 3 (CO 3):

1. For the following graph, find the longest path to all other vertices from vertex v0, using Bellman-Ford Algorithm.



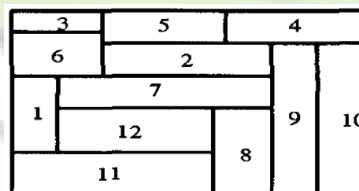


- Use the Longest Path Algorithm to find the longest path from vertex A, in the following graph.



#### Course Outcome 4 (CO 4):

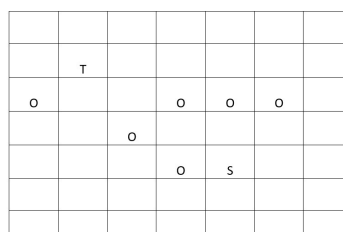
- Consider the following floorplan:



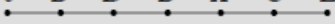
Draw the floorplan slicing tree and the polar graphs of the above floorplan.

#### Course Outcome 5 (CO 5):

- Perform LEE's Algorithm to find shortest path from S to T. Cells marked O indicate obstructions.



2. Draw Horizontal and Vertical Constraint Graph for the following Channel Routing.

|                                                                                   |          |          |          |          |          |          |
|-----------------------------------------------------------------------------------|----------|----------|----------|----------|----------|----------|
| <i>a</i>                                                                          | <i>b</i> | <i>c</i> | <i>d</i> | <i>e</i> | <i>f</i> | <i>g</i> |
| 0                                                                                 | B        | D        | B        | A        | C        | E        |
|  |          |          |          |          |          |          |
|  |          |          |          |          |          |          |
| <i>D</i>                                                                          | <i>C</i> | <i>E</i> | <i>F</i> | 0        | <i>A</i> | <i>F</i> |



MODEL QUESTION PAPER

QP CODE:

Pages: 5

Reg.No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027

Course Code: B24ECH61

Course Name: ELECTRONIC DESIGN AND AUTOMATION TOOLS

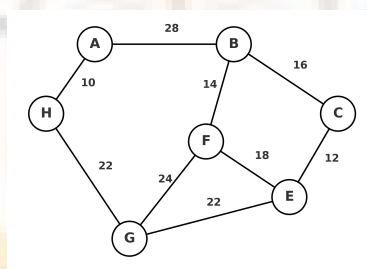
Max. Marks: 100

Duration: 3 hours

PART A

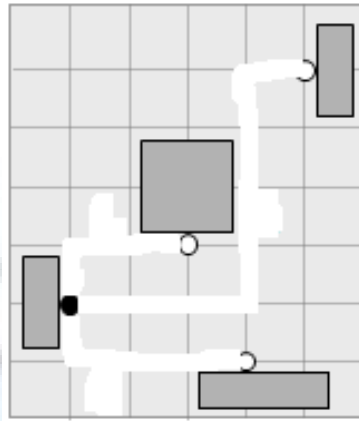
Answer all questions. Each question carries 3 marks

1. Define the following giving an example each: (a) Degree of a vertex (b) Subgraph (c) Directed Acyclic Graph (DAG).
2. Represent the following graph by Adjacency Matrix.



3. Write short note on (a) Full Custom Design (b) Standard Cell Design.
4. Explain any three parameters based on which Partitioning is performed.
5. What are the minimum distance rules in Design Rules for layout?
6. Write inequality expressions for minimum distance and maximum distance constraints between two rectangular edges.

7. For the following placement, calculate the wirelength by (a) Half Perimeter Method  
(b) Maximum Rectilinear Tree Method.



8. Represent the following floorplan using Sequence Pair approach.



9. How is Global Routing different from Detailed Routing?  
10. Define the following terms (a) Reserved Layer Model (b) Channel (c) Dogleg.

### ***PART B***

***Answer any one question from each module. Each question carries 14 marks***

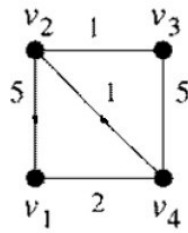
#### ***Module I***

11. a) List a DFS ordering of vertices for the graph shown in question 2. Starting node is H. (7)  
b) Perform topological sort on the graph and order the vertices. Starting node is H. (7)
12. a) List a BFS ordering of vertices for the graph shown in question 2. Starting node is H. (7)  
b) Give an application related to VLSI of BFS. (7)

#### ***Module II***

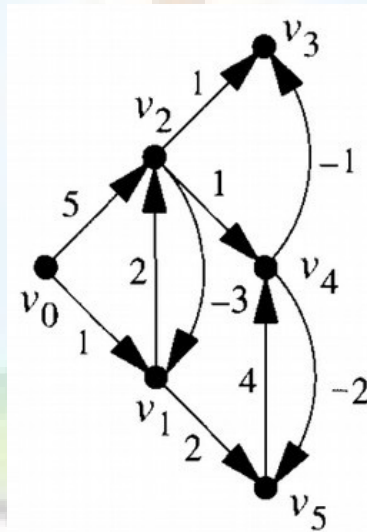
13. Draw the flowchart of VLSI Design Flow and explain the different stages.

14. Perform KL partitioning on the following graph. You may assume any initial partition of your choice.

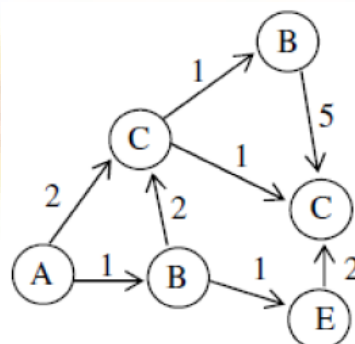


**Module III**

15. a) For the following graph, find the longest path to all other vertices from vertex  $v_0$ , using Bellman-Ford Algorithm. (10)



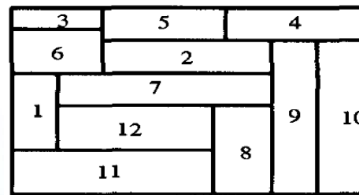
- b) What is the time complexity of Liao-Wong and Bellman-Ford Algorithms? (4)
16. a) Use the Longest Path Algorithm to find the longest path from vertex A, in the following graph. (8)



- b) What is the limitation of Longest Path Algorithm? (2)
- c) List two methods to find shortest path using Longest Path Algorithm. (4)

**Module IV**

17. Consider the following floorplan:



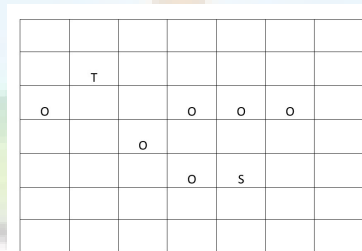
a) Draw the floorplan slicing tree of the above floorplan. (6)

b) Draw the polar graphs of above floorplan. (8)

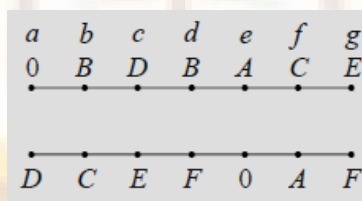
18. Given: Placement P with two fixed points p1 (100,175) and p2 (200,225), three free blocks a-c and four nets N1-N4. N1 (P1,a) N2 (a,b) N3 (b,c) N4 (c,P2). Find the coordinates of blocks (xa, ya), (xb, yb) and (xc, yc).

**Module V**

19. Perform LEE's Algorithm to find shortest path from S to T. Cells marked O indicate obstructions.



20. Draw Horizontal and Vertical Constraint Graph for the following Channel Routing.





| B24ECH62 | MIMO AND<br>MULTIUSER<br>COMMUNICA-<br>TION SYSTEMS<br>(Honours) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|----------|------------------------------------------------------------------|---|---|---|---|--------|-------------------------|
|          |                                                                  | 3 | 1 | 0 | 5 | 4      | 2024                    |

### Preamble

This course introduces the fundamental and advanced concepts of MIMO and multiuser communication systems used in modern wireless networks. It emphasizes the analysis of fading channels, multiuser detection techniques, diversity methods, and OFDM-based systems to enhance the capacity and reliability of wireless communication.

### Prerequisites

B24EC3T03 : ANALOG AND DIGITAL COMMUNICATION

### Course Outcomes

After the completion of the course, the student will be able to:

|      |                                                                                                                                                                |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Explain the fundamentals of MIMO systems, channel modeling, and the principles of spatial diversity and multiplexing [Understand]                              |
| CO 2 | Analyze the capacity and performance of MIMO systems under different channel conditions using mathematical models.[Understand, Analyze]                        |
| CO 3 | Apply various diversity and space-time coding schemes to enhance system reliability and efficiency.[Remember, Apply]                                           |
| CO 4 | Explain the operation of multi-user MIMO systems and describe basic linear precoding and beamforming techniques for interference management.[Understand,Apply] |
| CO 5 | Discuss emerging and advanced MIMO technologies such as Massive MIMO, CoMP, and MIMO-OFDM in modern wireless standards.[Understand, Analyze]                   |

### Mapping of Course Outcomes With Program Outcomes

### Assessment Pattern

### Mark Distribution

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    | 1    |      | 1    |      |      |      |      |       | 2     |
| CO 2 | 3    | 3    | 2    | 2    | 2    | 2    | 1    |      | 1    | 1     | 2     |
| CO 3 | 3    | 2    | 3    | 2    | 2    | 2    | 1    | 1    | 1    |       | 2     |
| CO 4 | 3    | 2    | 2    | 1    | 2    |      |      |      |      |       | 2     |
| CO 5 | 3    | 2    | 1    | 1    | 3    | 2    |      |      |      | 1     | 1     |

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         |                       | 20              | 10                                 |
| Understand       | 80                    | 40              | 60                                 |
| Apply            | 20                    | 20              | 20                                 |
| Analyse          |                       | 20              | 10                                 |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

## SYLLABUS

### MODULE 1

**Fundamentals of MIMO Systems :** Single-input single-output (SISO) vs. multiple-input multiple-output (MIMO). Concept of spatial diversity and spatial multiplexing. MIMO channel matrix representation, rank, and degrees of freedom. Introduction to capacity of MIMO channels.

### MODULE 2

**Capacity and Performance of MIMO Channels :** Capacity of deterministic and random MIMO channels. Ergodic and outage capacities. Water-filling principle and eigenmode transmission. Effect of channel state information (CSI). MIMO capacity under correlated fading.

### MODULE 3

**Diversity Techniques and Space-Time Coding:** Time, frequency, and spatial diversity. Alamouti scheme and orthogonal space-time block codes (OSTBC). Performance of space-time codes. Space-time trellis codes (STTC). Diversity–multiplexing trade-off.

### MODULE 4

**Multi-User MIMO (MU-MIMO) :** Uplink (Multiple Access Channel) and Downlink (Broadcast Channel) models. Sum capacity and rate region concepts. Linear precoding and beamforming (ZF, MMSE, Dirty Paper Coding concepts). Interference management and user scheduling. Channel feedback and CSI requirements.

### MODULE 5

**Advanced and Emerging MIMO Techniques :** Massive MIMO systems: architecture and benefits. Cooperative MIMO and relay-based MIMO. MIMO-OFDM systems and channel estimation. Introduction to multi-cell MIMO and coordinated multipoint (CoMP). Overview of MIMO in 5G and beyond.

### Text Books

1. “Wireless Communications” Andrea Goldsmith, Cambridge University Press 2005
2. “Fundamentals of Wireless Communications”, David Tse and Pramod Viswanath, Cambridge University Press, 2005.
3. “Introduction to Space Time Wireless Communications”, A Paulraj, Nabar and D Gore Cambridge University Press, 2003.
4. “Digital Communications”, Simon Haykin, John Wiley & Sons Pvt Ltd. 2001.

## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                    | No of Lecture/Tutorial Hours |
|-----|--------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                          | <b>8</b>                     |
| 1.1 | Review of wireless channel modeling: flat and frequency-selective fading | 1                            |
| 1.2 | Characteristics of MIMO channels – channel matrix and correlation        | 1                            |
| 1.3 | SISO vs. MIMO systems: motivation and benefits                           | 2                            |
| 1.4 | Concept of spatial diversity                                             | 1                            |
| 1.5 | Concept of spatial multiplexing and trade-offs                           | 1                            |
| 1.6 | MIMO channel rank, degrees of freedom                                    | 1                            |
| 1.7 | Introduction to MIMO channel capacity                                    | 1                            |
|     | <b>Module 2</b>                                                          | <b>9</b>                     |
| 2.1 | Capacity of deterministic and random MIMO channels                       | 1                            |
| 2.2 | Ergodic and outage capacities                                            | 1                            |
| 2.3 | Channel correlation and its effect on capacity                           | 1                            |
| 2.4 | Water-filling principle and eigenmode transmission                       | 2                            |
| 2.5 | Role of Channel State Information (CSI) at transmitter and receiver      | 2                            |
| 2.6 | MIMO capacity under correlated fading                                    | 2                            |
|     | <b>Module 3</b>                                                          | <b>9</b>                     |
| 3.1 | Time, frequency, and spatial diversity                                   | 1                            |
| 3.2 | Alamouti's $2 \times 1$ space-time block code                            | 2                            |
| 3.3 | Orthogonal space-time block codes (OSTBCs)                               | 1                            |
| 3.4 | Space-time trellis codes (STTCs) – concept and example                   | 2                            |
| 3.5 | Performance analysis of STBC and STTC                                    | 2                            |
| 3.6 | Diversity–multiplexing trade-off                                         | 1                            |
|     | <b>Module 4</b>                                                          | <b>11</b>                    |
| 4.1 | Uplink (Multiple Access Channel – MAC) model                             | 1                            |
| 4.2 | Downlink (Broadcast Channel – BC) model                                  | 1                            |
| 4.3 | Sum capacity and rate region concepts                                    | 2                            |
| 4.4 | Linear precoding: ZF, MMSE techniques                                    | 3                            |
| 4.5 | Dirty Paper Coding and beamforming overview                              | 2                            |
| 4.6 | Interference management and user scheduling                              | 2                            |
|     | <b>Module 5</b>                                                          | <b>9</b>                     |
| 5.1 | Massive MIMO – concept, architecture, benefits                           | 2                            |
| 5.2 | Cooperative and relay-based MIMO systems                                 | 1                            |
| 5.3 | MIMO-OFDM systems: principles and channel estimation                     | 2                            |
| 5.4 | Multi-cell MIMO and Coordinated Multipoint (CoMP)                        | 2                            |
| 5.5 | MIMO in 5G and beyond (6G trends)                                        | 2                            |
|     | <b>Total Hours</b>                                                       | <b>46 Hours</b>              |

## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1):**

1. Differentiate between flat and frequency-selective fading channels.
2. What is the significance of spatial diversity in MIMO systems?
3. Illustrate a simple  $2 \times 2$  MIMO channel matrix and discuss its properties.

### **Course Outcome 2 (CO 2):**

1. Define ergodic and outage capacity.
2. What is the effect of channel correlation on MIMO capacity?
3. Solve a problem on water-filling algorithm for a  $2 \times 2$  MIMO channel.

### **Course Outcome 3 (CO 3):**

1. What are the main advantages of space-time block coding (STBC)?
2. Explain the working of the Alamouti  $2 \times 1$  scheme.
3. Derive the received signal matrix for the Alamouti STBC.

### **Course Outcome 4 (CO 4):**

1. Differentiate between uplink (MAC) and downlink (BC) MIMO channels.
2. What is the principle behind Zero Forcing (ZF) precoding?
3. Describe how interference management is achieved using linear precoding.

### **Course Outcome 5 (CO 5):**

1. What are the key benefits of Massive MIMO in 5G networks?
2. Define Coordinated Multipoint (CoMP) and its application.
3. Compare CoMP and cooperative MIMO in terms of resource sharing and interference reduction.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24ECH62**

**Course Name: MIMO AND MULTIUSER COMMUNICATION SYSTEMS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define flat fading and frequency-selective fading channels.
2. Differentiate between SISO and MIMO systems.
3. Define channel rank and explain its significance in MIMO communication.
4. What is ergodic capacity?
5. Explain the concept of water-filling in MIMO capacity computation.
6. What is the principle of the Alamouti scheme?
7. Define diversity-multiplexing trade-off.
8. Differentiate between uplink (MAC) and downlink (BC) channels in MU-MIMO.
9. List the benefits of Massive MIMO systems.
10. What is Coordinated Multi-Point (CoMP) transmission

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**



11. a) Explain the concept of spatial diversity and spatial multiplexing in MIMO systems. (7)  
b) Derive the capacity expression for a flat-fading MIMO channel with perfect CSI. (7)
12. a) Discuss the relationship between channel matrix rank and achievable degrees of freedom in MIMO systems. (7)  
b) Compare SISO and MIMO systems in terms of performance, reliability, and complexity. (7)

**Module II**

13. a) Derive the ergodic and outage capacity expressions for a  $2 \times 2$  MIMO system. (8)  
b) Explain how channel correlation affects the MIMO capacity. (6)
14. a) Discuss the effect of transmitter and receiver CSI on MIMO channel capacity. (7)  
b) Illustrate the water-filling algorithm for MIMO capacity optimization. (7)

**Module III**

15. a) Derive the transmission matrix of the Alamouti space-time block code and show that it provides full diversity. (7)  
b) Explain the working of space-time trellis codes (STTC). (7)
16. a) Compare orthogonal space-time block codes (OSTBC) and space-time trellis codes (STTC). (7)  
b) Discuss the diversity-multiplexing trade-off with a neat sketch. (7)

**Module IV**

17. a) Explain the concepts of sum capacity and rate region in MU-MIMO systems. (8)  
b) Describe ZF and MMSE precoding techniques used in the downlink of MU-MIMO. (6)
18. a) Discuss the principles of Dirty Paper Coding (DPC) and its application in MU-MIMO broadcast channels. (7)  
b) Explain the role of CSI and feedback in user scheduling for MU-MIMO systems. (7)

**Module V**

19. a) Describe the architecture, advantages, and challenges of Massive MIMO systems. (7)  
b) Explain the working principle of MIMO-OFDM systems and its role in 5G. (7)
20. a) Compare Cooperative MIMO and Relay-based MIMO systems with suitable diagrams. (7)  
b) Write short notes on: (i) Multi-cell MIMO (ii) Coordinated Multi-Point (CoMP). (7)

| B24ECH63 | DETECTION<br>AND<br>ESTIMATION<br>THEORY<br>(Honours) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|----------|-------------------------------------------------------|---|---|---|---|--------|-------------------------|
|          |                                                       | 3 | 1 | 0 | 5 | 4      | 2024                    |

**Preamble**

This course provides a foundation in statistical methods for detecting and estimating signals in the presence of noise. It enables students to analyze and design optimal detectors and estimators used in communication, radar, and signal processing applications. The course bridges theory and practical decision-making under uncertainty.

**Prerequisites**

B24MA1T01 : LINEAR ALGEBRA AND MULTI VARIABLE CALCULUS

B24MA2T04A :STOCHASTIC PROCESSES AND NUMERICAL METHODS

B24EC2T05:SIGNALS AND SYSTEMS

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                          |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Explain the fundamental concepts of detection and estimation theory, including Gaussian and random signal models. [Understand]                           |
| <b>CO 2</b> | Apply statistical decision-making methods such as Neyman–Pearson, likelihood ratio test, and Bayesian approach for signal detection. [Apply]             |
| <b>CO 3</b> | Analyze the performance of detection systems using ROC curves, probability of error, and Bayes risk. [Apply]                                             |
| <b>CO 4</b> | Design and evaluate detectors and estimators for deterministic and random signals using matched filters, correlators, and linear models. [Apply,Analyze] |
| <b>CO 5</b> | Compare and implement estimation methods such as MVUE, CRLB, MLE, least squares, and Bayesian estimation for engineering applications.[Apply]            |

**Mapping of Course Outcomes With Program Outcomes****Assessment Pattern**

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    |      | 1    |      |      |      |      |      |       | 1     |
| CO 2 | 3    | 3    | 2    | 2    |      |      |      |      |      |       | 1     |
| CO 3 | 3    | 3    | 2    | 2    |      |      |      |      |      |       | 2     |
| CO 4 | 3    | 3    | 3    | 2    | 2    |      |      |      |      |       | 2     |
| CO 5 | 3    | 3    | 2    | 2    | 2    |      |      |      | 1    | 2     | 3     |

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 10                    | 10              | 10                                 |
| Understand       | 40                    | 40              | 40                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Introduction to Detection and Estimation Theory :** Fundamentals of detection theory, the mathematical detection problem. Fundamentals of estimation theory, the mathematical estimation problem. Review of Gaussian distribution. Application examples.

### MODULE 2

**Statistical Detection Theory I :** Hypothesis testing, classical approach, Neyman-Pearson theorem, likelihood ratio test, receiver operating characteristics, Bayesian approach, minimum probability of error, Bayes risk, multiple hypothesis testing.

### MODULE 3

**Statistical Detection Theory II:** Detection of deterministic signals, matched filters, detection of random signals, estimator/correlator, linear model, application examples.

### MODULE 4

**Statistical Estimation Theory I :** Minimum variance unbiased estimation, basics of Cramer-Rao Lower Bound, linear models, best linear unbiased estimation, application examples.

### MODULE 5

**Statistical Estimation Theory II :** Maximum likelihood estimation, least squares, Bayesian philosophy, minimum mean square error estimation, application examples.

### Text Books

1. S.M. Kay, "Fundamentals of Statistical Signal Processing" Vol I: Estimation Theory, Pearson, 3/e, 2010.
2. S.M. Kay, "Fundamentals of Statistical Signal Processing" Vol II: Detection Theory, Pearson, 3/e, 2010.
3. H. L. Van Trees, "Detection, Estimation, and Modulation Theory", Vol. I, John Wiley Sons, 1968
4. Monson H. Hayes, "Statistical Digital Signal Processing and Modelling" by, John Wiley Sons, 2002.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                | <b>No of Lecture/Tutorial Hours</b> |
|-----------|-----------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                             | <b>9</b>                            |
| 1.1       | Fundamentals of detection theory, review of probability and random variable | 2                                   |
| 1.2       | The mathematical detection problem .                                        | 2                                   |
| 1.3       | Fundamentals of estimation theory                                           | 1                                   |
| 1.4       | The mathematical estimation problem .                                       | 2                                   |
| 1.5       | Review of Gaussian distribution. Application examples.                      | 2                                   |
|           | <b>Module 2</b>                                                             | <b>9</b>                            |
| 2.1       | Hypothesis testing.                                                         | 2                                   |
| 2.2       | Classical approach, Neyman-Pearson theorem .                                | 2                                   |
| 2.3       | Likelihood ratio test, Receiver operating characteristics .                 | 2                                   |
| 2.4       | Bayesian approach, minimum probability of error, Bayes risk .               | 2                                   |
| 2.5       | Multiple hypothesis testing.                                                | 1                                   |
| 2.6       | Sharpening Spatial Filters: Laplacian filter.                               | 2                                   |
|           | <b>Module 3</b>                                                             | <b>9</b>                            |
| 3.1       | Detection of deterministic signals                                          | 1                                   |
| 3.2       | Matched filters                                                             | 2                                   |
| 3.3       | Detection of random signals .                                               | 2                                   |
| 3.4       | Estimator-correlator .                                                      | 2                                   |
| 3.5       | Linear model, application examples.                                         | 2                                   |
|           | <b>Module 4</b>                                                             | <b>9</b>                            |
| 4.1       | Minimum variance unbiased estimation.                                       | 2                                   |
| 4.2       | Basics of Cramer-Rao Lower Bound                                            | 2                                   |
| 4.3       | Linear models                                                               | 2                                   |
| 4.4       | Best linear unbiased estimation .                                           | 2                                   |
| 4.5       | Application examples .                                                      | 1                                   |
|           | <b>Module 5</b>                                                             | <b>9</b>                            |
| 5.1       | Maximum likelihood estimation.                                              | 2                                   |
| 5.2       | Least squares solution                                                      | 2                                   |
| 5.3       | Bayesian philosophy .                                                       | 2                                   |
| 5.4       | Minimum mean square error estimation                                        | 2                                   |
| 5.5       | Application examples                                                        | 1                                   |
|           | <b>Total Hours</b>                                                          | <b>45 Hours</b>                     |

## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1):**

1. Enumerate different applications which are using estimation and detection techniques.
2. Give the mathematical formulation of estimation and detection methods.
3. Give the significance of Bayes risk

### **Course Outcome 2 (CO 2):**

1. Describe Neyman-Pearson theorem (or Bayes risk or minimization of probability of error) and apply it to any binary hypothesis (eg. Signal in white Gaussian noise).
2. Derive/Obtain the matched filters for the detection of deterministic signals.
3. Derive/Obtain the estimator-correlator for the detection of random signals

### **Course Outcome 3 (CO 3):**

1. Explain M-ary hypothesis testing and its relevance in digital communication systems.
2. Derive the expression for probability of error in an M-ary orthogonal signal system.
3. Using Bayesian approach, obtain an estimator for any simple examples.

### **Course Outcome 4 (CO 4):**

1. Define unbiased estimator and derive the Cramer–Rao Lower Bound (CRLB).
2. Derive the Maximum Likelihood estimate (MLE) for the mean of a Gaussian random variable with known variance.
3. Compare the performance of the least squares (LS) and Maximum Likelihood (ML) estimation methods.

### **Course Outcome 5 (CO 5):**

1. Derive the expression for the Minimum Mean Square Error (MMSE) estimator.
2. Explain the difference between the MAP and MMSE estimators with an example.
3. Derive the expression for the MAP estimator when both the likelihood and prior are Gaussian



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24ECH63**

**Course Name: DETECTION AND ESTIMATION THEORY**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define the terms detection and estimation with suitable examples.
2. State the main assumptions of the Gaussian probability model used in detection theory.
3. What are the key differences between Neyman–Pearson and Bayesian criteria for hypothesis testing?
4. Explain the concept of Receiver Operating Characteristic (ROC) curve.
5. Write short notes on minimum probability of error criterion.
6. Define matched filter and explain its significance in the detection of deterministic signals.
7. What is the Cramer–Rao Lower Bound (CRLB) and why is it important in estimation theory?
8. Differentiate between biased and unbiased estimators with examples.
9. Explain the principle of Maximum Likelihood Estimation (MLE).
10. Compare MMSE and MAP estimation methods.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain the fundamentals of detection theory with a block diagram representation. (7)  
b) Derive the mathematical model for a simple detection problem and discuss Gaussian noise assumptions. (7)
12. a) Explain the mathematical estimation problem and the role of statistical models. (7)  
b) Discuss the importance of Gaussian distribution in detection and estimation. Give application examples. (7)

**Module II**

13. a) Derive the Likelihood Ratio Test (LRT) for binary hypothesis testing. (7)  
b) Explain the Neyman–Pearson theorem and its relevance to optimal detection. (7)
14. a) Discuss Bayesian hypothesis testing with prior probabilities and conditional risks. (7)  
b) Explain ROC curves and how they are used to evaluate detector performance. (7)

**Module III**

15. a) Explain the estimator-correlator structure and its application in signal detection. (7)  
b) Derive the matched filter detector for a deterministic signal in noise. (7)
16. a) Discuss the detection of random signals and the role of linear models. (7)  
b) Explain the application of matched filter in radar or communication systems. (7)

**Module IV**

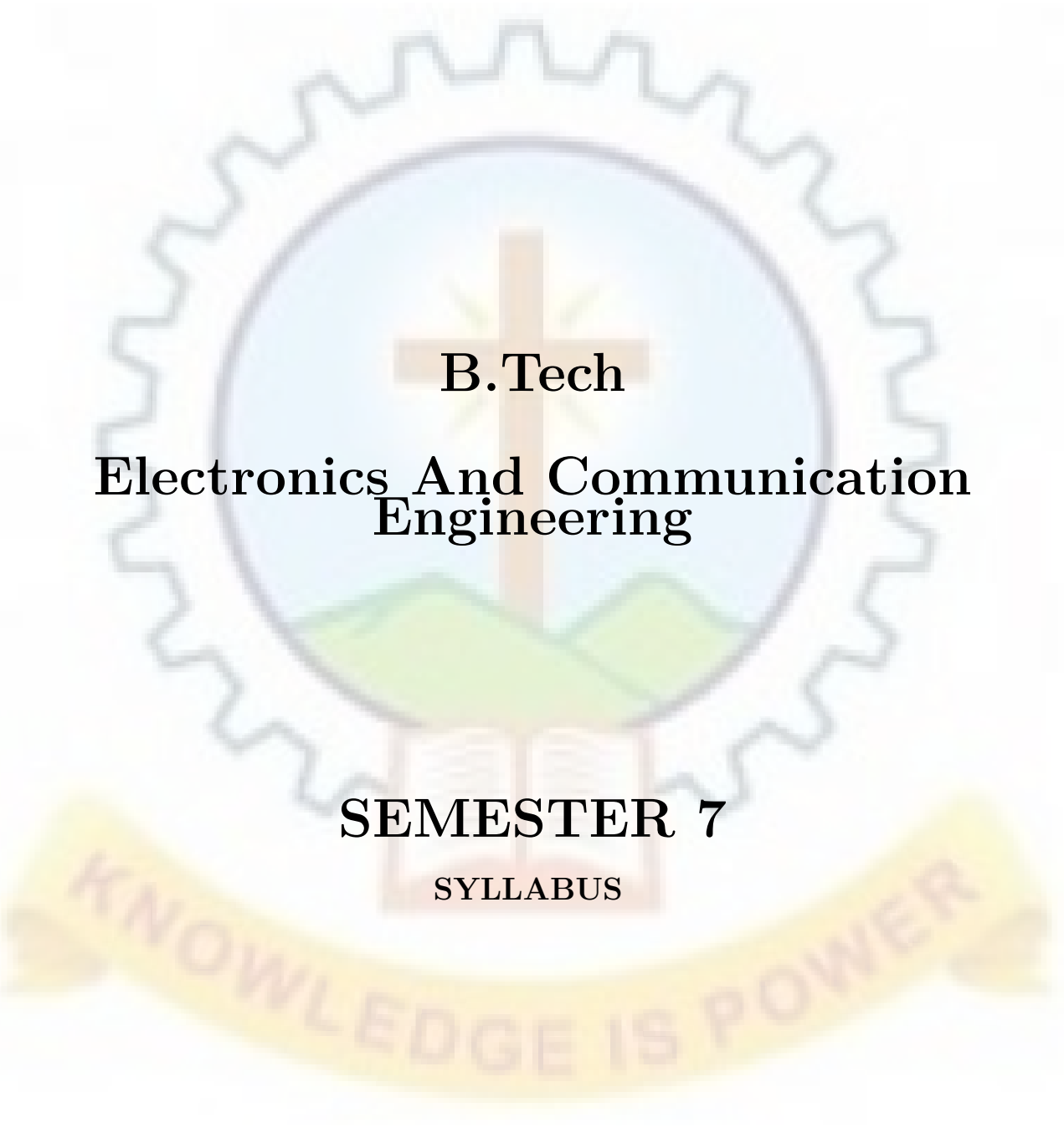
17. a) Define minimum variance unbiased estimation (MVUE) and derive its condition. (8)  
b) Explain the concept of Cramer–Rao Lower Bound (CRLB) with an example. (6)
18. a) Describe the Best Linear Unbiased Estimator (BLUE) and its derivation. (7)  
b) Illustrate the application of linear estimation models in signal processing. (7)

**Module V**

19. a) Derive the Maximum Likelihood Estimator (MLE) for the mean of a Gaussian random variable. (7)  
b) Explain the Bayesian estimation approach and derive the Minimum Mean Square Error (MMSE) estimator. (7)
20. a) Compare least squares, MLE, and Bayesian estimation methods in terms of assumptions and performance. (7)  
b) Discuss real-world applications of Bayesian estimation in communications or signal processing. (7)

# **MAR ATHANASIOUS COLLEGE OF ENGINEERING**

Government Aided, Autonomous Institution, Kothamangalam, Kerala,  
India

The logo of Mar Athanasius College of Engineering is a circular emblem with a gear-like outer border. Inside the circle, there is a blue upper half and a green lower half. A brown cross is centered in the blue area, with a sunburst at its intersection. Below the cross, there are green hills. At the bottom of the emblem, there is a yellow banner with the text 'KNOWLEDGE IS POWER' in red capital letters.

## **B.Tech Electronics And Communication Engineering**

### **SEMESTER 7**

#### **SYLLABUS**

**SEMESTER 7**

| SLOT         | COURSE NO. | COURSES                                   | L-T-P-S | HOURS     | CREDIT    |
|--------------|------------|-------------------------------------------|---------|-----------|-----------|
| A            | B24EC4T01  | INFORMATION THEORY AND CODING             | 2-1-0-4 | 3         | 3         |
| B            | B24EC4P3X  | PROGRAMME ELECTIVE III                    | 2-1-0-4 | 3         | 3         |
| C            | B24EC4P4X  | PROGRAMME ELECTIVE IV                     | 2-1-0-4 | 3         | 3         |
| D            | B24EC4G2X  | OPEN ELECTIVE II                          | 2-1-0-4 | 3         | 3         |
| E            | B24HU4T04  | DISASTER MANAGEMENT AND INDUSTRIAL SAFETY | 2-1-0-4 | 3         | 3         |
| G            | B24EC4L11  | COMMUNICATION LAB                         | 0-0-3-2 | 3         | 2         |
| H            | B24EC4L12  | PROJECT PHASE I                           | 0-0-6-2 | 6         | 3         |
| J            | B24EC4L13  | SEMINAR                                   | 0-0-4-1 | 4         | 2         |
| K            | B24EC4T02  | VIVA VOCE                                 | 0-0-0-0 | -         | 1         |
| M            | B24ECM7X   | MINOR                                     | 3-1-0-5 | 4         | 4         |
| N            | B24ECH7X   | HONOURS                                   | 3-1-0-5 | 4         | 4         |
| <b>TOTAL</b> |            |                                           |         | <b>36</b> | <b>23</b> |

**PROGRAMME ELECTIVE III**

| COURSE NO | Courses                             |
|-----------|-------------------------------------|
| B24EC4P31 | OBJECT ORIENTED PROGRAMMING IN JAVA |
| B24EC4P32 | ROBOTICS                            |
| B24EC4P33 | DIGITAL IMAGE PROCESSING            |
| B24EC4P34 | MIXED SIGNAL CIRCUIT DESIGN         |
| B24EC4P35 | RF CIRCUIT DESIGN                   |

**PROGRAMME ELECTIVE IV**

| COURSE NO | Courses                 |
|-----------|-------------------------|
| B24EC4P41 | EMBEDDED NETWORKS       |
| B24EC4P42 | MICROWAVE AND ANTENNAS  |
| B24EC4P43 | SECURE COMMUNICATION    |
| B24EC4P44 | ANALOG CMOS DESIGN      |
| B24EC4P45 | OPTO-ELECTRONIC DEVICES |

**OPEN ELECTIVE II**

| COURSE NO | Courses                |
|-----------|------------------------|
| B24EC4G21 | INTERNET OF THINGS     |
| B24EC4G22 | BIOMEDICAL ENGINEERING |
| B24EC4G23 | SECURE COMMUNICATION   |

|           |                           |
|-----------|---------------------------|
| B24EC4G24 | ENTERTAINMENT ELECTRONICS |
| B24EC4G25 | DIGITAL IMAGE PROCESSING  |

### MINOR

|                  |                |
|------------------|----------------|
| <b>COURSE NO</b> | <b>Courses</b> |
| B24ECM7X         | MINIPROJECT    |

### HONOURS

|                  |                                          |
|------------------|------------------------------------------|
| <b>COURSE NO</b> | <b>Courses</b>                           |
| B24ECH71         | RF MEMS                                  |
| B24ECH72         | DESIGN AND ANALYSIS OF ANTENNAS          |
| B24ECH73         | MULTIRATE SIGNAL PROCESSING AND WAVELETS |

| B24EC4T01 | INFORMATION<br>THEORY AND<br>CODING | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|-------------------------------------|---|---|---|---|--------|-------------------------|
|           |                                     | 2 | 1 | 0 | 4 |        |                         |

**Preamble**

This course is designed to understand the fundamentals of information theory, including the basics of both source coding and channel coding. It also introduces students to algebraic and probabilistic error-control codes, which are essential for reliable data transmission.

**Prerequisites**

B24MA1T01 : LINEAR ALGEBRA AND MULTI VARIABLE CALCULUS

B24MA2T04A : STOCHASTIC PROCESSES AND NUMERICAL METHODS

B24EC2T05 : SIGNALS AND SYSTEMS

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                                                                                 |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Explain the fundamental concepts of information theory, including entropy, mutual information, and apply basic source coding techniques such as Shannon–Fano and Huffman coding for efficient data representation. [Understand] |
| <b>CO 2</b> | Understand the characteristics of communication channels and evaluate channel capacity, including discrete memoryless and Gaussian channels, using fundamental information theory principles. [Evaluate]                        |
| <b>CO 3</b> | Explain the fundamentals of linear block codes and apply algebraic concepts such as Galois fields, generator matrices, and syndrome decoding for error detection and correction. [Understand, Apply]                            |
| <b>CO 4</b> | Describe the structure, construction, and decoding of important algebraic codes such as Hamming, cyclic, BCH, and Reed–Solomon codes for reliable data transmission. [Understand]                                               |
| <b>CO 5</b> | Explain the principles of convolutional and LDPC codes and apply decoding techniques such as the Viterbi algorithm and message-passing decoding for reliable communication. [Understand, Apply]                                 |



### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 3    | 1    | 1    | 2    |      |      |      |      |       | 3     |
| CO 2 | 3    | 3    | 1    | 1    | 2    |      |      |      |      |       | 3     |
| CO 3 | 3    | 3    | 1    | 1    | 2    |      |      |      |      |       | 3     |
| CO 4 | 3    | 3    | 1    | 1    | 2    |      |      |      |      |       | 3     |
| CO 5 | 3    | 3    | 1    | 1    | 2    |      |      |      |      |       | 3     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions

from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.



## SYLLABUS

### MODULE 1

**Entropy, Sources and Source Coding:** Introduction to Information Theory. Concept of information, units, entropy, marginal, conditional and joint entropies, relation among entropies, mutual information, information rate. Source coding: Instantaneous codes, construction of instantaneous codes, Kraft's inequality, coding efficiency and redundancy. Noiseless coding theorem, construction of basic source codes, Shannon – Fano Algorithm, Huffman coding.

### MODULE 2

**Channels and Channel Coding:** Discrete memoryless channels. Capacity of discrete memoryless channels – redundancy and efficiency of a channel, binary symmetric channel (BSC), Binary erasure channel (BEC) – capacity of band limited Gaussian channels. Continuous Sources and Channels: Differential Entropy, Mutual information, Waveform channels, Gaussian channels, Shannon – Hartley theorem, bandwidth, SNR trade off, capacity of a channel of infinite bandwidth, Shannon's limit.

### MODULE 3

**Introduction to Linear Block Codes:** Introduction to rings, fields, and Galois fields. Codes for error detection and correction – parity check coding – linear block codes – error detecting and correcting capabilities – generator and parity check matrices – Standard array and syndrome decoding.

### MODULE 4

**Important Classes of Algebraic codes:** Perfect codes, Hamming codes, encoding and decoding Cyclic codes, polynomial and matrix descriptions, generation of cyclic codes, decoding of cyclic codes BCH codes, Construction and decoding, Reed Solomon codes.

### MODULE 5

**Convolutional and LDPC Codes:** Convolutional Codes – encoding – time and frequency domain approaches, State Tree & Trellis diagrams – transfer function and minimum free distance – Maximum likelihood decoding of convolutional codes – The Viterbi Algorithm. Sequential decoding. Low-density parity check (LDPC) codes. Tanner graph representation. Message-passing decoding for transmission over binary erasure channel.

**Text Books**

1. Joy A Thomas, Thomas M Cover, Elements of Information Theory, Wiley-Interscience.
2. David JC McKay, Information Theory, Inference and Learning Algorithms, Cambridge University Press.
3. RG Gallager, Principles of digital communication, Cambridge University Press.
4. Simon Haykin, Digital Communication Systems, Wiley.
5. Ron M Roth, Introduction to Coding Theory, Cambridge University Press.



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                            | No of Lecture/Tutorial Hours |
|-----|------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                  | <b>8</b>                     |
| 1.1 | Introduction to Information Theory. Concept of information, units.                                               | 1                            |
| 1.2 | Entropy, marginal, conditional and joint entropies.                                                              | 1                            |
| 1.3 | Relation among entropies, mutual information, information rate.                                                  | 2                            |
| 1.4 | Source coding: Instantaneous codes, construction of instantaneous codes.                                         | 1                            |
| 1.5 | Kraft's inequality, coding efficiency and redundancy.                                                            | 1                            |
| 1.6 | Noise-less coding theorem, construction of basic source code.                                                    | 1                            |
| 1.7 | Shannon – Fano Algorithm, Huffman coding.                                                                        | 1                            |
|     | <b>Module 2</b>                                                                                                  | <b>8</b>                     |
| 2.1 | Discrete memoryless channels. Capacity of discrete memoryless channels – redundancy and efficiency of a channel. | 2                            |
| 2.2 | Binary symmetric channel (BSC), Binary erasure channel (BEC) – capacity of band limited Gaussian channel.        | 2                            |
| 2.3 | Continuous Sources and Channels: Differential Entropy, Mutual information.                                       | 1                            |
| 2.4 | Waveform channels, Gaussian channel.                                                                             | 1                            |
| 2.5 | Shannon – Hartley theorem, bandwidth, SNR trade off.                                                             | 1                            |
| 2.6 | Capacity of a channel of infinite bandwidth, Shannon's limit.                                                    | 1                            |
|     | <b>Module 3</b>                                                                                                  | <b>7</b>                     |
| 3.1 | Introduction to rings, fields, and Galois fields.                                                                | 2                            |
| 3.2 | Codes for error detection and correction – parity check coding.                                                  | 1                            |
| 3.3 | Linear block codes–error detecting and correcting capabilities.                                                  | 1                            |
| 3.4 | Generator and parity check matrices.                                                                             | 2                            |
| 3.5 | Standard array and syndrome decoding.                                                                            | 1                            |
|     | <b>Module 4</b>                                                                                                  | <b>7</b>                     |
| 4.1 | Perfect codes, Hamming codes.                                                                                    | 1                            |
| 4.2 | Encoding and decoding Cyclic codes.                                                                              | 1                            |
| 4.3 | Polynomial and matrix descriptions.                                                                              | 1                            |
| 4.4 | Generation of cyclic codes, decoding of cyclic codes.                                                            | 2                            |
| 4.5 | Generation of cyclic codes, decoding of cyclic codes BCH codes-Construction and decoding, Reed Solomon codes.    | 2                            |
|     | <b>Module 5</b>                                                                                                  | <b>10</b>                    |

|     |                                                                                                  |                 |
|-----|--------------------------------------------------------------------------------------------------|-----------------|
| 5.1 | Convolutional Codes – encoding – time and frequency domain approaches.                           | 1               |
| 5.2 | State Tree & Trellis diagrams.                                                                   | 2               |
| 5.3 | Transfer function and minimum free distance – Maximum likelihood decoding of convolutional code. | 2               |
| 5.4 | The Viterbi Algorithm. Sequential decoding.                                                      | 2               |
| 5.5 | Low-density parity check (LDPC) codes. Tanner graph representation.                              | 2               |
| 5.6 | Message-passing decoding for transmission over binary erasure channel.                           | 1               |
|     | <b>Total Hours</b>                                                                               | <b>40 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Create the second order extended source by taking probabilities of 9 symbols in the extended source as the product of every possible combinations of two symbols from the original source.
2. Generate Huffman code for the extended source symbols and find the entropy, average codeword length and efficiency of the code.

#### Course Outcome 2 (CO 2):

1. Let the input symbol probabilities corresponding to symbol 0 and 1 be  $\alpha$  and  $(1 - \alpha)$  respectively. For different values of  $\alpha$  ranging from 0 to 1, find the joint probability matrix,  $P(X,Y)$  and output probability,  $P(Y)$ .
2. Find mutual information,  $I(X; Y) = H(Y) - H(Y/X)$  for each value of  $\alpha$ . Plot the  $I(X; Y)$  versus  $\alpha$  graph and observe the channel capacity.

#### Course Outcome 3 (CO 3):

1. Generate all possible codewords by multiplying the message vector of length,  $k$  with  $G$ .
2. Create the  $k \times n$  generator matrix,  $G$  of  $(n, k)$  LBC.

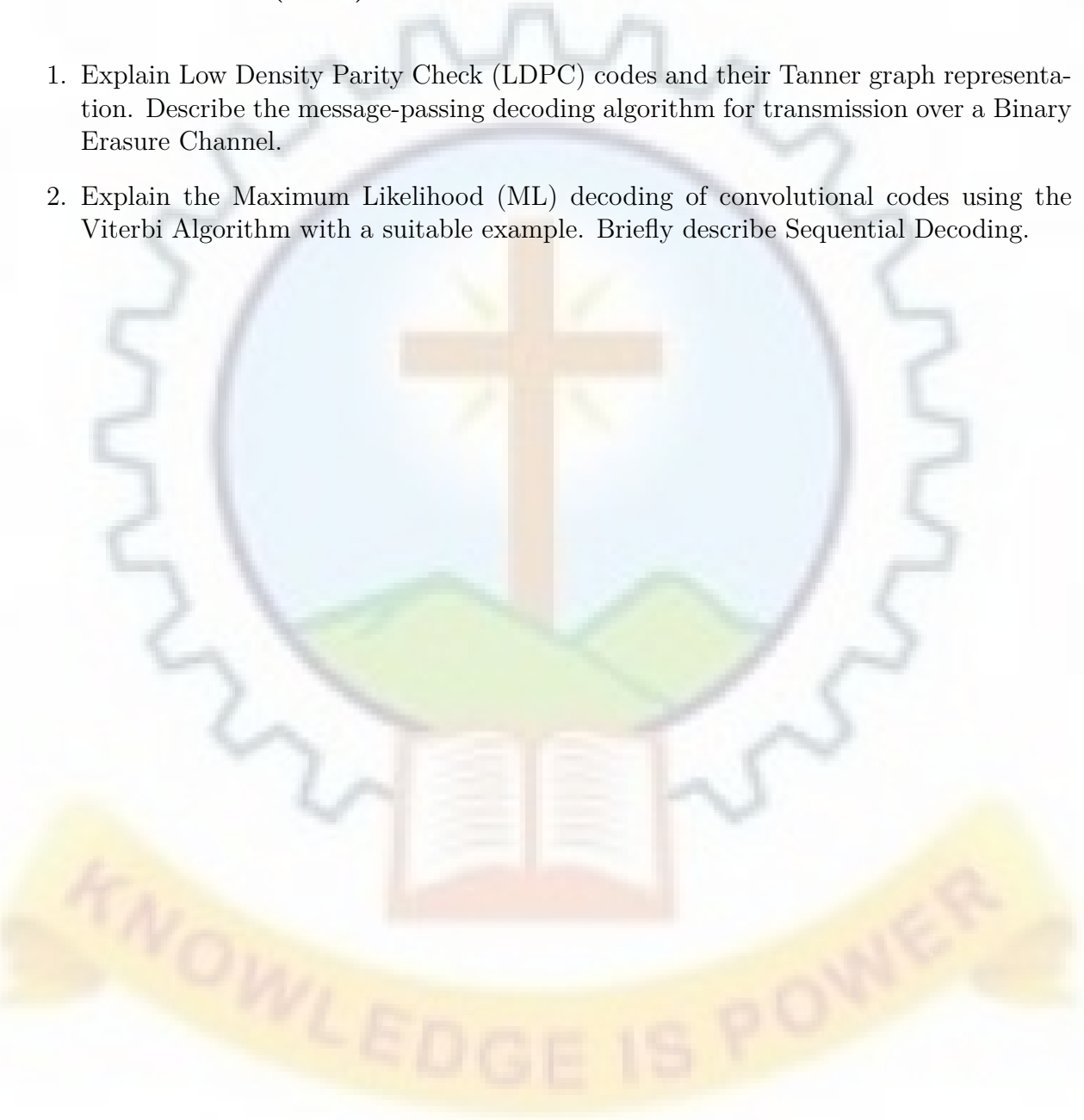
#### Course Outcome 4 (CO 4):



1. Find the generator polynomial for single, double and triple error correcting BCH code of block length,  $n = 7$ .
2. Determine the parameters  $(n,k,d)$  for BCH code with block length  $n=15$  capable of correcting two errors.

**Course Outcome 5 (CO 5):**

1. Explain Low Density Parity Check (LDPC) codes and their Tanner graph representation. Describe the message-passing decoding algorithm for transmission over a Binary Erasure Channel.
2. Explain the Maximum Likelihood (ML) decoding of convolutional codes using the Viterbi Algorithm with a suitable example. Briefly describe Sequential Decoding.



MODEL QUESTION PAPER

QP CODE:

Pages: 5

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027

Course Code: B24EC4T01

Course Name: INFORMATION THEORY AND CODING

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. A source emits one of four symbols,  $S_0, S_1, S_2, S_3$  with probabilities  $1/3, 1/6, 1/4$  and  $1/4$  respectively. The successive symbols emitted by the source are statistically independent. Calculate the entropy of the source.
2. Explain instantaneous codes with example.
3. State Shannon's channel coding theorem. What is its significance in digital communication system?
4. An analog signal band limited to 'B' Hz is sampled at Nyquist rate. The samples are quantized into 4 levels. The quantization levels are assumed to be independent and occur with probabilities:  $p_1 = p_4 = 1/8, p_2 = p_3 = 3/8$ . Find the information rate of the source assuming  $B = 100\text{Hz}$ .
5. List the properties of group. Give an example.
6. Show that  $C = \{0000, 1100, 0011, 1111\}$  is a linear code. What is its minimum distance?
7. Explain generation of systematic cyclic code using polynomial description.
8. List the features of Reed Solomon code.
9. Draw a  $(3,2,1)$  convolutional encoder with generator sequences,  
 $g_1^{(1)} = (11), g_1^{(2)} = (01), g_1^{(3)} = (11), g_2^{(1)} = (01), g_2^{(2)} = (10), g_2^{(3)} = (10)$ .

10. Draw the tanner graph of rate 1/3 LDPC code for the given parity check matrix.

$$H = \begin{bmatrix} 1 & 1 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$$

### PART B

**Answer any one question from each module. Each question carries 14 marks**

#### Module I

11. a) The joint probability of a pair of random variables is given below. Determine  $H(X,Y)$ ,  $H(X/Y)$ ,  $H(Y/X)$  and  $I(X,Y)$ . Verify the relationship between joint, conditional and marginal entropies.

$$P(X,Y) = \begin{bmatrix} \frac{1}{3} & \frac{1}{3} \\ 0 & \frac{1}{3} \end{bmatrix} \quad (10)$$

- b) Explain uniquely decodable and prefix-free property of source code. (4)

12. a) Find the binary Huffman code for the source with probabilities  $\{1/3, 1/5, 1/5, 2/15, 2/15\}$ . Also find the efficiency of the code. (9)

- b) Prove that  $H(Y) \geq H(Y/X)$ . (5)

#### Module II

13. a) A voice grade channel of the telephone network has a bandwidth of 3.4 KHz. Calculate channel capacity of the telephone channel for signal to noise ratio of 30 dB. Also determine the minimum SNR required to support information transmission through the telephone channel at the rate of 4800 bits/sec. (7)

- b) Derive the expression for channel capacity for binary erasure channel. (7)

14. a) A binary channel has the following noise characteristic.

$$P(Y,X) = \begin{bmatrix} \frac{2}{3} & \frac{1}{3} \\ \frac{1}{3} & \frac{2}{3} \end{bmatrix}$$

If the input symbols are transmitted with probabilities  $3/4$  and  $1/4$  respectively, find  $I(X;Y)$ . Also compute channel capacity and what are the input symbol probabilities that correspond to the channel capacity. (9)

- b) State Shannon Hartley theorem and explain the significance of Shannon limit. (5)

#### Module III

15. a) The parity check matrix of (7,4) linear block code is given as

$$H = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 \end{bmatrix}$$

Compute the minimum distance of the code and find its error detection and correcting capability. Suppose that the received codeword,  $r = (1001111)$ . Determine whether the received codeword is in error? If so, form the decoding table and obtain the correct codeword. (9)

- b) List the properties of vector space. Define subspace. (5)

16. a) The parity bits of a (8, 4) linear systematic block code are generated by  $c_5 = d_1 + d_2 + d_4$ ,  $c_6 = d_1 + d_2 + d_3$ ,  $c_7 = d_1 + d_3 + d_4$ ,  $c_8 = d_2 + d_3 + d_4$  (+ sign denotes modulo-2 addition) where  $d_1, d_2, d_3$  and  $d_4$  are message bits and  $c_5, c_6, c_7$  and  $c_8$  are parity bits. Find generator matrix  $G$  and parity check matrix  $H$  for this code. Draw the encoder circuit. (7)

- b) Explain the construction of finite field from polynomial ring with the help of an example. (7)

#### Module IV

17. a) Consider a (7, 4) cyclic code with generator polynomial,  $g(x) = 1 + x + x^3$ . Express the generator matrix and parity-check matrix in systematic and non-systematic form. (8)

- b) Find the generator polynomial for single, double and triple error correcting BCH code of block length,  $n = 15$ . (6)

18. a) Draw syndrome circuit for a (7,4) cyclic code generated by  $g(x) = 1 + x + x^3$ . If the received vector  $r$  is [0010110] what is the syndrome of  $r$ ? Explain the circuit with a table showing the contents of the syndrome register. (8)

- b) What are the features of Hamming code? Find the parity check matrix for (15, 11) Hamming code. (6)

#### Module V

19. a) Draw the state diagram of a convolution encoder with rate  $1/3$  and constraint length 3 for generator sequences  $g^{(1)} = (100)$ ,  $g^{(2)} = (101)$ ,  $g^{(3)} = (111)$ . (7)

- b) Explain message passing decoding algorithm for LDPC codes with the help of an example. (7)

20. For a (2,1,2) convolutional encoder with generator sequences  $g^{(1)} = (111)$ ,  $g^{(2)} = (101)$  Draw Trellis and perform Viterbi decoding on this trellis for the received sequence {01, 10, 10, 11, 01, 01, 11} and obtain the estimate of the transmitted sequence. (14)

| B24EC4P31 | OBJECT<br>ORIENTED<br>PROGRAMMING<br>IN JAVA | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|----------------------------------------------|---|---|---|---|--------|-------------------------|
|           |                                              | 2 | 1 | 0 | 4 |        |                         |

**Preamble**

This course equip learners with problem-solving skills by decomposing problems into object-oriented designs and implementing them using Java. It covers core OOP concepts, inheritance, exception and event handling, multithreading, and window-based graphics, enabling development of GUI, and web applications.

**Prerequisites**

B24ES1T01A PROBLEM SOLVING AND PROGRAMMING TECHNIQUES  
B24ES1L01 PROGRAMMING LAB

**Course Outcomes**

After the completion of the course, the student will be able to:

|      |                                                                                                                                                                                    |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Identify the advantages of Java programming over procedure-oriented programming.[Understand]                                                                                       |
| CO 2 | Understand the features of object-oriented programming such as encapsulation, polymorphism, inheritance, and composition of systems based on object identity.[Understand, Analyze] |
| CO 3 | Demonstrate the use of inheritance, interfaces, packages, and exception handling mechanisms to develop structured and reusable Java applications.[Understand, Apply]               |
| CO 4 | Implement file handling and input/output operations using Java stream classes for efficient data storage, retrieval, and manipulation.[Understand, Apply]                          |
| CO 5 | Develop basic graphical user interface (GUI) applications using AWT/Swing components and perform database operations using JDBC.[Analyze, Apply]                                   |

**Mapping of Course Outcomes With Program Outcomes**

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    |      |      | 1    | 2    | 2    |      |      |       | 2     |
| CO 2 | 3    | 3    |      |      | 2    | 2    | 2    |      | 1    |       | 2     |
| CO 3 | 3    | 2    | 3    |      | 2    | 1    | 1    | 2    | 1    | 1     | 2     |
| CO 4 | 2    | 2    | 2    | 1    | 2    |      |      |      |      |       | 2     |
| CO 5 | 2    | 2    | 3    | 1    | 3    |      |      |      |      |       | 2     |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         |                       |                 |                                    |
| Understand       | 80                    | 80              | 80                                 |
| Apply            |                       | 20              | 10                                 |
| Analyse          | 20                    |                 | 10                                 |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.



## **SYLLABUS**

### **MODULE 1**

**Introduction to Java Programming :** Object Oriented Programming Concepts, Compare with procedure-oriented programming, Features of Java Language, Java Architecture (JDK, JRE and JVM), Structure of Java Program. Literals, Data Types, Variables, Operators, if else statement, switch statement, while, do while, for and enhanced for loop, break, continue, comma statement.

### **MODULE 2**

**Fundamentals of Java :** One-Dimensional Array, Multi-Dimensional Array, String Class. Class Fundamentals, Declaring Objects, Object Reference, Introduction to Methods, Constructors, this Keyword, Method Overloading, Using Objects as Parameters, Returning Objects, Recursion, Access Control, Static Members, Final Variables, Inner Classes, Command-Line Arguments, Variable Length Arguments.

### **MODULE 3**

**More features of Java :** Inheritance – Super Class, Sub Class, The Keyword super, protected Members, Calling Order of Constructors, Method Overriding, the Object class, Abstract Classes and Methods, Using final with Inheritance. Packages and Interfaces – Defining Package, CLASSPATH, Access Protection, Importing Packages, Interfaces. Exception Handling – Checked Exceptions, Unchecked Exceptions, try Block and catch Clause, Multiple catch Clauses, Nested try Statements, throw, throws and finally.

### **MODULE 4**

**Input and Output Classes :** I/O Streams, The File Class, Byte Stream (Input Stream, Output Stream), Disk File Handling (FileInputStream, FileOutputStream), Memory Handling, Filtered Byte Streams (BufferedInputStream, BufferedOutputStream, DataInputStream, DataOutputStream), SequenceInputStream, ObjectOutputStream, ObjectInputStream, Random Access File, Character Stream (CharArrayReader, CharArrayWriter, InputStreamReader, OutputStreamWriter, FileWriter, FileReader, BufferedReader, BufferedWriter)

### **MODULE 5**

**GUI Programming :** - The AWT class hierarchy, Introduction to Swing, Swing Vs AWT, Hierarchy for Swing components, Overview of some Swing components – JButton, JLabel, JTextField, JTextArea, simple Swing applications, Layout management. Java DataBase Connectivity (JDBC) - overview, creating and executing queries.

### Text Books

1. Java Fundamentals–A Comprehensive Introduction, Herbert Schildt and Dale Skrien, TMH.
2. Core Java: An Integrated Approach – Dr R Nageswara Rao
3. Paul Deitel, Harvey Deitel, Java How to Program, Early Objects 11th Edition, Pearson, 2018.
4. Programming with Java – A primer by E. Balagurusamy, Tata Mc-Graw Hill Publication
5. Programming in Java2 by Dr. K. Somasundaram, Jaico Books.

### COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                                                | No of Lecture/Tutorial Hours |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                                                      | <b>11</b>                    |
| 1.1 | Object Oriented Programming Concepts, Compare with procedure-oriented programming                                                                                                    | 2                            |
| 1.2 | Features of Java Language, Java Architecture (JDK, JRE and JVM)                                                                                                                      | 2                            |
| 1.3 | Structure of Java Program. Literals, Data Types, Variables, Operators                                                                                                                | 2                            |
| 1.4 | if else statement, switch statement, while, do while                                                                                                                                 | 2                            |
| 1.5 | for and enhanced for loop                                                                                                                                                            | 2                            |
| 1.6 | break, continue, comma statement                                                                                                                                                     | 1                            |
|     | <b>Module 2</b>                                                                                                                                                                      | <b>10</b>                    |
| 2.1 | One-Dimensional Array, Multi-Dimensional Array                                                                                                                                       | 2                            |
| 2.2 | String Class, Class Fundamentals, Declaring Objects, Object Reference                                                                                                                | 2                            |
| 2.3 | Introduction to Methods, Constructors, this Keyword, Method Overloading, Using Objects as Parameters, Returning Objects, Recursion, Access Control, Static Members, Final Variables, | 4                            |
| 2.4 | Inner Classes, Command-Line Arguments, Variable Length Arguments.                                                                                                                    | 2                            |
|     | <b>Module 3</b>                                                                                                                                                                      | <b>10</b>                    |
| 3.1 | Inheritance – Super Class, Sub Class, The Keyword super, protected Members, Calling Order of Constructors                                                                            | 1                            |
| 3.1 | Method Overriding, the Object class, Abstract Classes and Methods, Using final with Inheritance.                                                                                     | 2                            |
| 3.3 | Packages and Interfaces – Defining Package, CLASSPATH, Access Protection, Importing Packages, Interfaces                                                                             | 3                            |
| 3.4 | Exception Handling – Checked Exceptions, Unchecked Exceptions, try Block and catch Clause,                                                                                           | 3                            |
| 3.5 | Multiple catch Clauses, Nested try Statements, throw, throws and finally.                                                                                                            | 1                            |

|     |                                                                                                                                                                  |                 |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
|     | <b>Module 4</b>                                                                                                                                                  | <b>6</b>        |
| 4.1 | I/O Streams, The File Class, Byte Stream (Input Stream, Output Stream), Disk File Handling (FileInputStream, FileOutputStream)                                   | 2               |
| 4.2 | Memory Handling, Filtered Byte Streams (BufferedInputStream, BufferedOutputStream, DataInput-Stream, DataOutputStream), SequenceInputStream, ObjectOutputStream, | 1               |
| 4.3 | ObjectInput-Stream, Random Access File, Character Stream (CharArrayReader, CharArrayWriter, Input-StreamReader,                                                  | 1               |
| 4.4 | OutputStreamWriter, FileWriter, FileReader, Buffered-Reader, Buffered-Writer)                                                                                    | 2               |
|     | <b>Module 5</b>                                                                                                                                                  | <b>5</b>        |
| 5.1 | The AWT class hierarchy, Introduction to Swing, Swing Vs AWT, Hierarchy for Swing components                                                                     | 1               |
| 5.2 | Overview of some Swing components – JButton, JLabel, JTextField, JTextArea, simple Swing applications,                                                           | 2               |
| 5.3 | Java DataBase Connectivity (JDBC) - overview, creating and executing queries.                                                                                    | 2               |
|     | <b>Total Hours</b>                                                                                                                                               | <b>44 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the structure of a Java program with an example.
2. Compare Object-Oriented Programming and Procedure-Oriented Programming.
3. Explain the switch statement with syntax and example.
4. Compare for loop, while loop, and do-while loop.

#### Course Outcome 2 (CO 2):

1. Describe the String class and any four string methods.
2. Explain class fundamentals in Java.
3. Explain how objects are declared and initialized.
4. Explain the concept of constructors with an example.

**Course Outcome 3 (CO 3):**

1. Describe the calling order of constructors in inheritance.
2. Explain method overriding with example.
3. Explain the Object class and its importance.
4. Write a Java program showing the use of throw and throws.

**Course Outcome 4 (CO 4):**

1. Explain the use of SequenceInputStream.
2. Explain ObjectInputStream and ObjectOutputStream.
3. Write a Java program to read data from a file using FileInputStream.
4. Write a Java program to write data to a file using FileOutputStream.
5. Write a program to copy contents from one file to another using byte streams.

**Course Outcome 5 (CO 5):**

1. Compare Swing and AWT.
2. Explain the hierarchy of Swing components.
3. Describe the working of JButton and JLabel.
4. Explain JTextField and JTextArea with examples.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2029**

**Course Code: B24EC4P31**

**Course Name: OBJECT ORIENTED PROGRAMMING IN JAVA**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Explain the role of JVM in Java architecture.
2. Write a Java program to find the largest of two numbers using if-else statement.
3. Explain the concept of recursion.
4. Write a Java program to demonstrate method overloading.
5. What are protected members?
6. Explain the concept of packages and access protection.
7. What is the purpose of BufferedReader?
8. Describe disk file handling using FileInputStream and FileOutputStream.
9. What is the purpose of JButton?
10. Explain the basic architecture of JDBC.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. Describe the features of Java and explain why Java is considered a platform-independent programming language. (14)
12. Explain different looping statements in Java including while, do-while, for, and enhanced for loop with suitable examples. (14)

**Module II**

13. Write a Java program to perform matrix addition using multidimensional arrays. (14)
14. Write a Java program to create a class Student with data members and methods to display student details. (14)

**Module III**

15. Explain exception handling in Java. Describe checked and unchecked exceptions, try-catch block, multiple catch clauses, and finally block. (14)
16. Write a Java program using an abstract class and abstract method to calculate the area of different shapes. (14)

**Module IV**

17. Explain character stream classes such as FileReader, FileWriter, BufferedReader, and BufferedWriter with examples. (14)
18. Write a Java program to read data from a file using FileInputStream and display it on the screen. (14)

**Module V**

19. Explain the hierarchy of Swing components and describe the features of important components. (14)
20. Write a Java program to connect to a database using JDBC and display records from a table. (14)



| <b>B24EC4P32</b> | <b>ROBOTICS</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF INTRODUCTION</b> |
|------------------|-----------------|----------|----------|----------|----------|---------------|-----------------------------|
|                  |                 | 2        | 1        | 0        | 4        |               |                             |

**Preamble**

Preamble: The objective of this course is to introduce to the students the emerging field of robotics by imparting the fundamental knowledge on the design and control of robots, their multi-disciplinary engineering aspects and applications..

**Prerequisites**

B24MA1T01: LINEAR ALGEBRA AND MULTIVARIABLE CALCULUS

B24EC3T02 : CONTROL SYSTEMS

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                   |
|-------------|---------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Attain a thorough understanding of different types of Robots and their applications. [Understand] |
| <b>CO 2</b> | Select appropriate sensors and actuators based on the robotic applications. [Apply]               |
| <b>CO 3</b> | Perform kinematic and dynamic analyses for robots. [Analyze]                                      |
| <b>CO 4</b> | Carry out the design and control of a simple robot. [Understand, Apply]                           |
| <b>CO 5</b> | Integrate mechanical and electrical hardware for making a robotic device. [Understand, Apply]     |

**Mapping of Course Outcomes With Program Outcomes**

|             | <b>PO 1</b> | <b>PO 2</b> | <b>PO 3</b> | <b>PO 4</b> | <b>PO 5</b> | <b>PO 6</b> | <b>PO 7</b> | <b>PO 8</b> | <b>PO 9</b> | <b>PO 10</b> | <b>PO 11</b> |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|
| <b>CO 1</b> | 3           | 1           | 3           |             | 3           |             | 1           |             |             | 3            | 2            |
| <b>CO 2</b> | 3           | 3           | 3           | 3           | 3           | 2           |             |             |             | 3            | 2            |
| <b>CO 3</b> | 3           | 3           | 3           | 2           | 2           | 2           |             |             |             | 3            | 2            |
| <b>CO 4</b> | 3           | 3           | 3           | 3           | 1           | 3           |             |             |             | 3            | 2            |
| <b>CO 5</b> | 3           | 3           | 2           | 3           | 2           |             |             |             |             | 3            | 2            |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Introduction to Robotics:** Definition and Origin of Robotics. Robot Anatomy. Robot Specifications. Robot Characteristics – Accuracy, Precision, and Repeatability. Classification of Robots. Advantages and Disadvantages of Robots. Robot Structure - Types of Joints and End Effectors, Mechanisms and Manipulators. Common Kinematic Arrangements. Degree of Freedom. Robot Coordinates. Reference Frames. Robot Workspace. Areas of Application for Robots.

### MODULE 2

**Introduction to Sensors and Actuation Systems for Robots:** Actuators: Types of Robotic Drive Systems and Actuators: Hydraulic, Pneumatic and Electric drives. Transmission: Gears, Timing Belts and Bearings. Parameters for selection of actuators. Specification. Areas of Application for: Stepper Motor, Servo Motor and Brushless DC Motor. Microprocessor Control of Motors. Speed Control using PWM and Direction Control using H-Bridge. Sensors: Types and Applications of Sensors in Robotics: Position, Displacement and Velocity Sensors. Tactile Sensors for Contact and Proximity Assessment. Strain Gauge based Force and Torque Sensors. Tachometers, etc. Robotic Vision Systems- Introduction to Cameras, Imaging, Sensing and Digitization. Vision Applications in Robotics.

### MODULE 3

**Introduction to Robot Kinematics and Dynamics:** Introduction to Kinematics: Position and Orientation of Objects. Rotation. Euler Angles. Rigid Motion Representation using Homogenous Transformation Matrix. Kinematic Modelling: Translation and Rotation Representation, Coordinate Transformation, Forward and Inverse Kinematics. Forward Kinematics-Link Coordinates, Denavit-Hartenberg Representation, Application of DH Convention to Different Serial Kinematic Arrangements. Inverse Kinematics – General Properties of Solutions, Kinematic Decoupling, Velocity Kinematics – Derivation of the Jacobian, Application of Velocity Kinematics for Serial Manipulators, Importance of Singularities. Introduction to Dynamic Modelling: Forward and Inverse Dynamics- Equations of Motion using Euler-Lagrange formulation, Newton Euler Formulation.

### MODULE 4

**Introduction to Robot Control:** Basics of Control: Open Loop- Closed Loop, Transfer Functions, Control Laws: P, PD, PID, Linear and Non-linear Controls; Control Hardware and Interfacing; Embedded Systems: Microcontroller Architecture and Integration

with Sensors, Actuators, Components. Introduction to Robot Programming – Programming Methods, Robot Language Classification, Robot Language Structure, Elements and its Functions. Motion, End-Effector and Sensor Commands in VAL Programming Language. Simple Programs.

## **MODULE 5**

**Recent Developments in Robotics:** Mobile Robots: Mobile Robot Kinematics, Navigation. Humanoid Robotics: Biped Locomotion, Imitation Learning. Collaborative Robots: Collaborative Robot, Collaborative Operation, Applications. Artificial Intelligence in Robotics: Applications in Unmanned Systems, Defense, Medical, Industries, etc. Industrial Applications of Robots in Material Handling and Assembly. Robotics and Automation for Industry 4.0., Robot Safety. Social Robotics.

### **Text Books**

1. S.K. Saha, Introduction to Robotics, Tata McGraw Hill, 2nd Edition, 2014
2. Saeed B. Niku, Introduction to Robotics: Analysis, Systems, Applications, John Wiley & Sons, 2nd Edition, 2011. Wiley & Sons, 2nd Edition, 2011.
3. Spong and Vidyasagar, Robot Dynamics and Control, John Wiley & Sons, 1990.
4. Mikell P. Groover, et al., Industrial Robotics – Technology, Programming and Applications, McGraw Hill, 2nd Edition, 2012
5. John. J. Craig, Introduction to Robotics: Mechanics and Control, PHI, 2005.
6. Ashitava Ghosal, Robotics, Fundamental concepts and analysis, OXFORD University Press, 2006
7. Fu, K.S., Gonzalez, R.C., Lee, C.S.G., Robotics, Control, Sensing, Vision and Intelligence, McGraw-Hill, 1987.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                                                                                                                                                                                                                | <b>No of Lecture/Tutorial Hours</b> |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                                                                                                                                                                                                                             | <b>5</b>                            |
| 1.1       | Definition and Origin of Robotics.                                                                                                                                                                                                                                                                          | 1                                   |
| 1.2       | Characteristics, Classification, Advantages and Disadvantages of Robots.                                                                                                                                                                                                                                    | 1                                   |
| 1.3       | Robot Structure, and Common Kinematic Arrangements.                                                                                                                                                                                                                                                         | 1                                   |
| 1.4       | Concepts of Degree of Freedom (DOF), Coordinates, Reference Frames, Workspace in Robotics.                                                                                                                                                                                                                  | 1                                   |
| 1.5       | Areas of Application for Robots.                                                                                                                                                                                                                                                                            | 1                                   |
|           | <b>Module 2</b>                                                                                                                                                                                                                                                                                             | <b>9</b>                            |
| 2.1       | Robotic Drive Systems and Actuators: different types of drive systems used in robotics,different transmission systems used in robots and their specific applications..                                                                                                                                      | 1                                   |
| 2.2       | Types and Applications of Actuators in Robotics:different deciding parameters for selecting appropriate actuators for robots, specific applications for stepper motors, servo motors and brushless DC motors in robotics?                                                                                   | 2                                   |
| 2.3       | Types and Applications of Sensors in Robotics:different position sensors, displacement sensors , velocity sensors,tactical sensors,contact and proximity sensors, force and torque sensors,tachometers help in robotic operation and application?.                                                          | 2                                   |
| 2.4       | Control of Motors in Robotics:microprocessor-based control in electricmotors,speed control using pulse-width modulation,direction control using H-Bridge.                                                                                                                                                   | 1                                   |
| 2.5       | Robotic Vision Systems:role of cameras in robots, imaging, sensing and the vision applications of robots?.                                                                                                                                                                                                  | 2                                   |
| 2.6       | Control of Robotics: Conduct exercises to develop small control programs for joints/links/end effectors of robots..                                                                                                                                                                                         | 1                                   |
|           | <b>Module 3</b>                                                                                                                                                                                                                                                                                             | <b>7</b>                            |
| 3.1       | Introduction to Kinematics: specify the position and orientation of links and joints in robotics. common methods for describing robot orientations,rigid motion representation using a homogenous transformation matrix..                                                                                   | 1                                   |
| 3.2       | Kinematic Modelling:the position and orientation of an end effector of a robot under translation and/or rotation,coordinate transformation method,transformations between the coordinate frames attached to different robotic links and joints,the purposes for forward and inverse kinematics in robotics. | 1                                   |



|     |                                                                                                                                                                                                                                             |          |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 3.3 | Forward Kinematics: compute the position of the end effector from joint parameters, Denavit-Hartenberg representation, application of D-H convention to different serial kinematic arrangements..                                           | 2        |
| 3.4 | Inverse Kinematics:prediction of the joint angles from the known coordinates of the end effector of a robot, kinematic decoupling in robotic manipulators?                                                                                  | 1        |
| 3.5 | Velocity Kinematics:relationship between linear and angular velocities of the end effector to the joint velocities, application of velocity kinematics to serial robots, different singularities that affect the degree of freedom of robot | 1        |
| 3.6 | Introduction to Dynamic Modelling:functions of forward and inverse dynamicsin robotics, development of the equations of motion using the Euler-Lagrange formulation,role of Newton-Euler formulation in the dynamic modelling of robots?    | 1        |
|     | <b>Module 4</b>                                                                                                                                                                                                                             | <b>6</b> |
| 4.1 | Basics of Control: Describe the basic control parameters and systems used in robotics, P, PD, PID, Linear and Non-linear Controls in robotic practices?                                                                                     | 1        |
| 4.2 | Control Hardware and Interfacing:advantages of using the embedded system in robotics,integrate microcontrollers to sensors, actuators and components within a robotic system                                                                | 1        |
| 4.3 | Introduction to Robot Programming:different programming methods for robots,classification of robot languages ,structure, elements, and functions of robot language..                                                                        | 2        |
| 4.4 | Introduction to Robot Programming: role of variable assembly language (VAL) programming in robotics, common commands used for motion, end effector and sensors                                                                              | 1        |
| 4.5 | Introduction to Robot Programming: Using simple programs, conduct exercises to develop the robot programming skills of students.                                                                                                            | 1        |
|     | <b>Module 5</b>                                                                                                                                                                                                                             | <b>8</b> |
| 5.1 | Mobile Robots:introduction, kinematics change with mobile robots, navigation of mobile robots..                                                                                                                                             | 1        |
| 5.2 | Humanoid Robotics:difference between humanoid robots and other types,biped locomotion, challenges involved in the static and dynamic balance of biped robots, application of imitation learning in humanoid robots                          | 2        |
| 5.3 | Collaborative Robots:introduction, collaborative operation for robots, applications of collaborative robots?                                                                                                                                | 1        |
| 5.4 | Artificial Intelligence (AI) in Robotics:.applications of AI in robotics,AIin unmanned robotic systems , applications of AI-based robots in the defense, medical, industrial and other domains.                                             | 2        |



|                    |                                                                                                                                                                                                                                                 |                 |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 5.5                | Industrial Applications of Robots:applications of robots in different industries,role in material handling and assembly, contribution of robotics towards Industry 4.0.                                                                         | 1               |
| 5.6                | Robot Ethics, Robot Safety and Social Robotics,ethical practices necessary for the design, production and application of robots today, aspects of occupational safety and health of humans when robots are used in the workplace, social robots | 1               |
| <b>Total Hours</b> |                                                                                                                                                                                                                                                 | <b>35 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Write down the brief history and growth of robotics.
2. Describe the different basic components of a robotic system and their functions.
3. Explain the principle of degree of freedom or connectivity in terms of robotic joints.

#### Course Outcome 2 (CO 2):

1. With neat sketches elucidate the working of any one type of tactile sensor used for contact and proximity assessment.
2. Describe the imaging, sensing and digitization processes in a basic robotic vision system.
3. List and justify any two applications where pneumatic actuators are preferred over hydraulic ones.

#### Course Outcome 3 (CO 3):

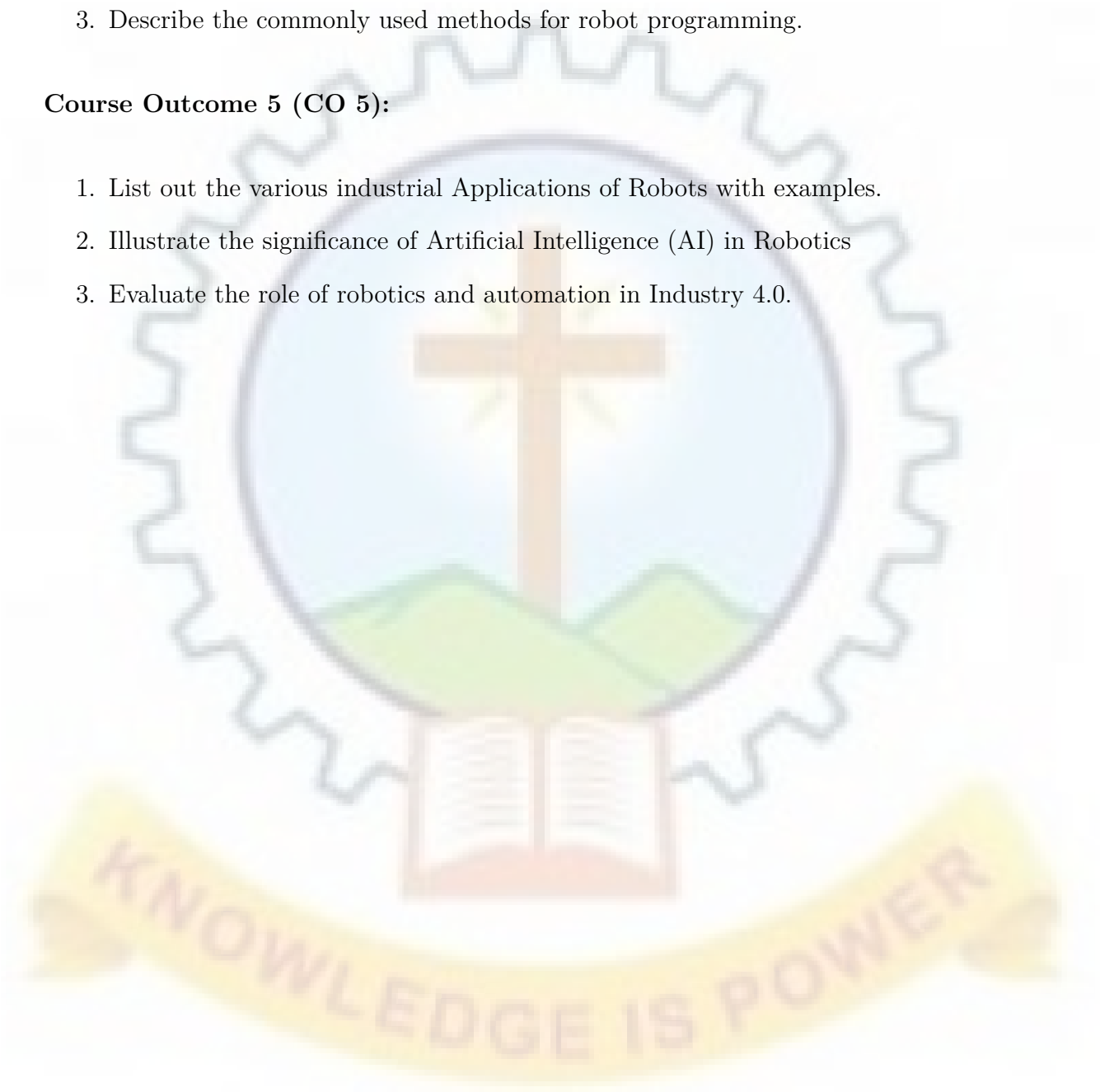
1. Describe the techniques and methods for the representation of position and orientation of objects, their translation and rotation, as well as the coordinate transformation in the workspace of a robot.
2. Explain the Denavit-Hartenberg (D-H) convention for selecting frames of reference in robotics applications.
3. Apply the D-H convention to represent the different serial kinematic arrangements fitted with various end effectors.

**Course Outcome 4 (CO 4):**

1. Explain the process of control of position and force of manipulators in robots.
2. Illustrate the working of a robotic device using the closed-loop control system with a suitable example.
3. Describe the commonly used methods for robot programming.

**Course Outcome 5 (CO 5):**

1. List out the various industrial Applications of Robots with examples.
2. Illustrate the significance of Artificial Intelligence (AI) in Robotics
3. Evaluate the role of robotics and automation in Industry 4.0.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 3**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24EC4P32**

**Course Name: ROBOTICS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. List out the different criteria based on which robots are classified.
2. What are the basic components of a robot?
3. Determine the advantages of using electric drive systems in robots.
4. Identify the sensors used in robots for sensing position and velocity.
5. Recognize the need for Denavit-Hartenberg convention in robotics.
6. Describe joint angle, joint distance, link length and link twist.
7. How is the speed of an electric motor controlled using a microprocessor?
8. Distinguish between linear and rotary hydraulic actuation mechanisms.
9. Find any four non-industrial applications of robots
10. Substantiate the need for robot ethics.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Describe the commonly used types of joints and end effectors in robots. (8)  
b) Explain the basic structure of any robotic system. How each component is different from the others in terms of its functionality? (6)
12. a) Discuss the common kinematic arrangements in robots and find out the degree of freedom for each. (8)  
b) Write notes on terms like accuracy, precision, and repeatability in connection with a robotic system. (6)

#### **Module II**

13. a) Compare among hydraulic, pneumatic and electric types of robotic drives and mention the specific area of application for each. (8)  
b) Describe how direction control is carried out on electric motors in robots using H- Bridge. (6)
14. a) Discuss the different characteristics of tactile sensors. Describe with the help of a neat diagram the working of commonly used tactile sensors (8)  
b) Elaborate on the imaging, sensing and digitization processes in robotic vision systems. (6)

#### **Module III**

15. a) A frame 'B' was rotated about the x-axis 90°, then, it was translated about the current a-axis 3 inches before it was rotated about z-axis 90°. Finally, it was translated about the current a-axis 5 inches. i) Write an equation that describes the motion. ii) Find the final location of a point P (1, 5, 4)<sup>T</sup> attached to the frame relative to the reference frame. (8)  
b) Distinguish between rotation matrix and homogenous transformation matrix. (6)
16. a) Describe the common kinematic arrangements of robots based on Cartesian-coordinate and Cylindrical-coordinate systems. (8)  
b) What is the relevance of Jacobian operator in velocity kinematics? What is meant by manipulator Jacobian?. (6)

#### **Module IV**

17. a) Discuss the different control schemes of robots (5)  
b) Give 2 examples each for motion, end effector, and sensor commands in VAL programming language. (9)
18. a) Compare performance of open loop, P, PI and PID controllers. (8)  
b) What is task level programming? Name the main categories of robot programming languages. (6)

#### **Module V**

19. a) What are mobile robots? What are the different classes of mobile robots? (8)  
b) What are collaborative robots? Mention any 2 applications of collaborative robots. (6)
20. a) What is the contribution of robotics towards industry 4.0? (8)  
b) What are social robots? How they are supposed to help humans? (6)



| <b>B24EC4P33</b> | <b>DIGITAL IMAGE PROCESSING</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF INTRODUCTION</b> |
|------------------|---------------------------------|----------|----------|----------|----------|---------------|-----------------------------|
|                  |                                 | 2        | 1        | 0        | 4        |               |                             |

**Preamble**

This course introduces the fundamental concepts and techniques of Digital Image Processing, focusing on image representation, enhancement, compression, segmentation, morphological processing, and restoration.

**Prerequisites**

B24EC2T05 : SIGNALS AND SYSTEM

**Course Outcomes**

After the completion of the course, Students will learn both spatial and frequency domain approaches for improving image quality and extracting meaningful information from images. The course also covers practical techniques such as filtering, edge detection, transform methods, and image compression standards. By the end of the course, students will be able to understand and apply basic image processing algorithms for analysis and enhancement of digital images. Enhancement of Digital Images.

|             |                                                                                                                                                                            |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Explain the fundamental concepts of digital image processing, including image sampling, quantization, pixel relationships, and colour image models. [Remember, Understand] |
| <b>CO 2</b> | Illustrate and apply spatial domain image enhancement techniques such as gray level transformations, histogram processing, and spatial filtering. (Understand, apply)      |
| <b>CO 3</b> | Apply frequency domain techniques including DFT, frequency filters, and image compression methods for image enhancement and data reduction. (Apply)                        |
| <b>CO 4</b> | Apply image segmentation techniques and morphological operations for extracting and processing meaningful image regions. (Apply)                                           |
| <b>CO 5</b> | Apply image restoration and geometric transformation techniques to improve degraded images. (Apply)                                                                        |

**Mapping of Course Outcomes With Program Outcomes**



|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 1    |      |      | 1    |      |      |      |      |       | 1     |
| CO 2 | 2    | 3    |      | 1    | 2    |      |      |      |      |       | 1     |
| CO 3 | 2    | 2    |      | 1    | 3    |      |      |      |      |       | 1     |
| CO 4 | 2    | 2    | 1    | 1    | 3    |      |      |      |      |       | 1     |
| CO 5 | 2    | 2    | 1    | 1    | 3    |      |      |      |      |       | 1     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Introduction to Digital Image Processing:** Introduction to images and types of images, applications of digital image processing in various fields, fundamental steps in image processing, elements of digital image processing systems, image characteristics such as brightness, contrast, hue, saturation, and Mach band effect, 2D image sampling and quantization, and basic pixel relationships including neighbors, connectivity, and distance measures between pixels. Colour image fundamentals-RGB, CMY, HIS models.

### MODULE 2

**Image Enhancement in the Spatial Domain:** Basic Gray Level Transformations, Histogram Processing, Enhancement Using Arithmetic and Logic operations, Basics of Spatial Filters, Smoothing Spatial Filters: Low pass filters, Order Statistics filters; Sharpening Spatial Filters: Laplacian filter

### MODULE 3

**Image Enhancement in the Frequency Domain:** 2D Image transforms: DFT, its properties, Walsh transform, Hadamard transform, Haar transform . Frequency Domain Filtering: Ideal and Butterworth Low pass and High pass filters, Homomorphic Filtering.

**Image Compression** Need for Image Compression , Redundancy in Images, Classification of Redundancy in Images , Image Compression Scheme, Classification of Image Compression Schemes ,Transform Based Compression, JPEG 2000 Standards.

### MODULE 4

**Image segmentation: Classification of Image segmentation techniques:** Point, Line and Edge Detection, Gradient and Laplacian based edge detection, Region approach, Segmentation based on thresholding.

**Morphological Image Processing** Mathematical Morphology ,Structuring Elements, Morphological Image Processing, Basic Set Theory ,Logical Operations,Standard Binary Morphological Operations,Dilation- and Erosion-based Operations ,Properties of Morphological operations.

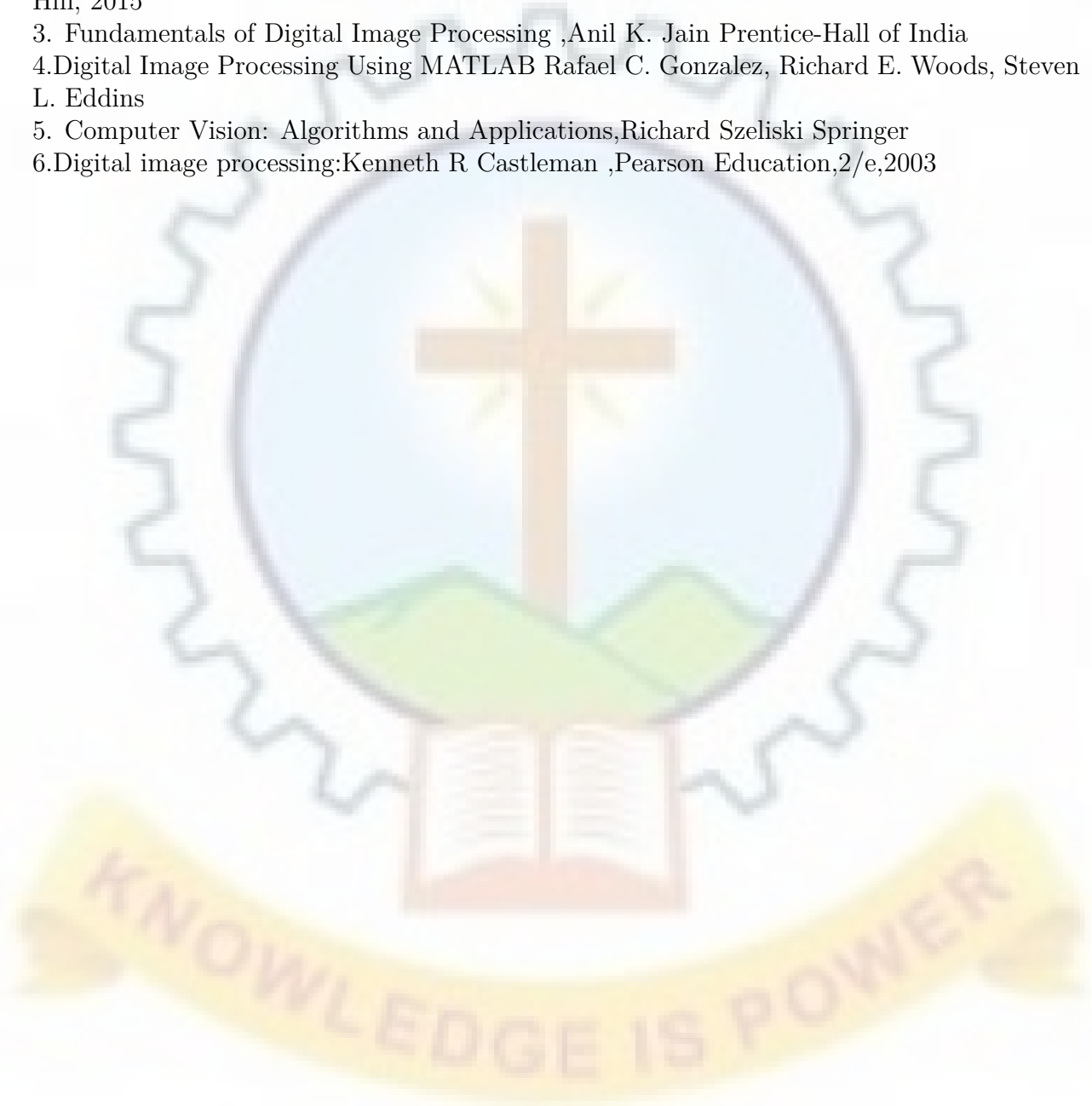
### MODULE 5

**Image Restoration:** Degradation model, Unconstraint restoration- Lagrange multiplier

and constraint restoration Inverse filtering- removal of blur caused by uniform linear motion, Wiener filtering, Geometric transformations-spatial transformations.

**Text Books**

1. Digital Image Processing, Gonzalez Rafael C, Pearson Education, 2009
2. Digital image processing, S Jayaraman, S Esakkirajan, T Veerakumar, Tata Mc Graw Hill, 2015
3. Fundamentals of Digital Image Processing ,Anil K. Jain Prentice-Hall of India
4. Digital Image Processing Using MATLAB Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins
5. Computer Vision: Algorithms and Applications, Richard Szeliski Springer
6. Digital image processing: Kenneth R Castleman ,Pearson Education, 2/e, 2003



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                          | No of Lecture/Tutorial Hours |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                | <b>8</b>                     |
| 1.1 | Introduction to images and types of images, applications of digital image processing in various fields, fundamental steps in image processing. | 1                            |
| 1.2 | fundamental steps in image processing, elements of digital image processing systems.                                                           | 1                            |
| 1.3 | image characteristics such as brightness, contrast, hue, saturation, and Mach band effect.                                                     | 2                            |
| 1.4 | 2D image sampling and quantization, and basic pixel relationships including neighbors, connectivity, and distance measures between pixel       | 2                            |
| 1.5 | Colour image fundamentals-RGB, CMY, HIS models.                                                                                                | 2                            |
|     | <b>Module 2</b>                                                                                                                                | <b>10</b>                    |
| 2.1 | Basic Gray Level Transformations.                                                                                                              | 2                            |
| 2.2 | Histogram Processing.                                                                                                                          | 2                            |
| 2.3 | Enhancement Using Arithmetic and Logic operations.                                                                                             | 1                            |
| 2.4 | Basics of Spatial Filters.                                                                                                                     | 1                            |
| 2.5 | Smoothing Spatial Filters: Low pass filters, Order Statistics filters.                                                                         | 2                            |
| 2.6 | Sharpening Spatial Filters: Laplacian filter.                                                                                                  | 2                            |
|     | <b>Module 3</b>                                                                                                                                | <b>10</b>                    |
| 3.1 | 2D Image transforms: DFT, its properties.                                                                                                      | 2                            |
| 3.2 | Walsh transform, Hadamard transform, Haar transform.                                                                                           | 3                            |
| 3.3 | Frequency Domain Filtering: Ideal and Butterworth Low pass and High pass filters.                                                              | 1                            |
| 3.4 | Homomorphic Filtering.                                                                                                                         | 1                            |
| 3.5 | Image Compression Need for Image Compression , Redundancy in Images, Classification of Redundancy in Images .                                  | 1                            |
| 3.6 | Image Compression Scheme, Classification of Image Compression Schemes .                                                                        | 1                            |
| 3.7 | Transform Based Compression, JPEG 2000 Standards.                                                                                              | 1                            |
|     | <b>Module 4</b>                                                                                                                                | <b>10</b>                    |
| 4.1 | Classification of Image segmentation techniques. Point, Line and Edge Detection                                                                | 1                            |
| 4.2 | Gradient and Laplacian based edge detection                                                                                                    | 2                            |
| 4.3 | Region approach, Segmentation based on thresholding.                                                                                           | 1                            |
| 4.4 | Morphological Image Processing Dilation and Erosion.                                                                                           | 2                            |
| 4.5 | Mathematical Morphology , Structuring Elements, Morphological Image Processing,                                                                | 1                            |

|     |                                                                                  |                 |
|-----|----------------------------------------------------------------------------------|-----------------|
| 4.6 | Basic Set Theory ,Logical Operations,Standard Binary Morphological Operations.   | 2               |
| 4.7 | ,Dilation- and Erosion-based Operations ,Properties of Morphological operations. | 1               |
|     | <b>Module 5</b>                                                                  | <b>7</b>        |
| 5.1 | Degradation model.                                                               | 1               |
| 5.2 | Unconstrained restoration- Lagrange multiplier and constraint restoration        | 1               |
| 5.3 | restoration Inverse filtering- removal of blur caused by uniform linear motion.  | 2               |
| 5.4 | Weiner filtering. Geometric transformations-spatial transformations              | 3               |
|     | <b>Total Hours</b>                                                               | <b>45 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the process of image sampling and quantization and illustrate how they affect digital image representation.
2. Describe the basic relationships between pixels such as adjacency, connectivity, and distance measures used in digital image processing.
3. Compare the RGB, CMY, and HSI colour models and explain their applications in digital image processing.

#### Course Outcome 2 (CO 2):

1. Explain different gray level transformation techniques used for image enhancement with suitable examples.
2. Describe histogram processing techniques and explain how histogram equalization improves image contrast.
3. Apply spatial filtering techniques such as smoothing and sharpening filters for image enhancement.

#### Course Outcome 3 (CO 3):

1. Explain the concept of 2-D Discrete Fourier Transform (DFT) and its role in frequency domain image processing.
2. Apply frequency domain filters such as ideal, Butterworth, and Gaussian filters for image enhancement.
3. Explain the need for image compression and describe transform-based compression techniques such as JPEG.

**Course Outcome 4 (CO 4):**

1. Explain different image segmentation techniques such as point detection, line detection, and edge detection.
2. Describe the region-based segmentation approach and its advantages.
3. Apply morphological operations such as dilation and erosion in image processing.

**Course Outcome 5 (CO 5):**

1. Explain the image degradation model used in image restoration.
2. Apply inverse filtering and Wiener filtering techniques for restoring degraded images.
3. Explain geometric transformations and their role in spatial image transformation.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24EC4P33**

**Course Name: DIGITAL IMAGE PROCESSING**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. List the fundamental steps in digital image processing.
2. Define distance measures between pixels and mention any two types.
3. Explain histogram equalization.
4. What are Laplacian and Sobel operators? State their uses.
5. Compare Ideal, Butterworth and Gaussian filters.
6. List the advantages of Walsh transform over Fourier Transform..
7. What is Canny edge detector? List its major steps.
8. Illustrate the use of derivative operation in edge detection.
9. What is inverse filtering?
10. List any three causes that can result in image degradation.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Elaborate on the importance of 2D sampling in digital image processing and discuss the process of quantization (8)

b) Define the terms brightness, contrast and hue with respect to digital images. (6)

12. a) Discuss the conceptual relationship between the RGB and HIS colour models with neat sketches. (10)

b) Differentiate between spatial resolution and intensity resolution. (4)

### Module II

13. a) Explain the concept of image averaging in spatial domain methods. Discuss its role in reducing noise and enhancing image quality. Provide examples and discuss the limitations of image averaging. (7)

b) Compute the 2-D DFT of a  $2 \times 2$  matrix given

$$x[m, n] = \begin{bmatrix} 201 & 124 \\ 345 & 267 \end{bmatrix}$$

(7)

14. a) Perform histogram equalization of the following image

$$\begin{bmatrix} 3 & 7 & 6 & 2 & 0 \\ 2 & 4 & 6 & 1 & 1 \\ 4 & 7 & 2 & 5 & 4 \\ 3 & 0 & 6 & 2 & 1 \\ 5 & 7 & 5 & 1 & 2 \end{bmatrix}$$

(7)

b) Explain the point operations used in image enhancement. (7)

### Module III

15. a) Illustrate the algorithmic steps to generate Haar basis. . (7)

b) For the image segment

$$I = \begin{bmatrix} 2 & 2 \\ 1 & 3 \end{bmatrix}$$

compute the transform coefficients using DFT

(7)

16. a) State and prove any two properties of 2D DFT. . (7)

b) Explain the steps involved in homomorphic filtering. (7)

### Module IV

17. a) Explain region splitting and merging in image segmentation with neat schematics.. (8)  
b) Discuss Canny edge detection in detail. (6)
18. a) Explain the method of global thresholding for image segmentation (7)  
b) Explain the use of Hough transform for line detection. (7)

**Module V**

19. a) Explain the concept of a degradation model in image restoration. Discuss how it represents the relationship between the original and degraded images. (7)  
b) Explain image restoration using inverse filtering techniques. Give its limitations.
20. a) Discuss the Wiener filtering technique in image restoration. Explain how it considers both the characteristics of the image and the noise to enhance the. (7)  
b) Explain the various geometric transformations. (7)

| B24EC4P34 | MIXED SIGNAL<br>CIRCUIT<br>DESIGN | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|-----------------------------------|---|---|---|---|--------|-------------------------|
|           |                                   | 2 | 1 | 0 | 4 | 3      | 2024                    |

### Preamble

This course aims to analyse various CMOS analog and digital mixed signal circuits.

### Prerequisites

B24EC1T04: Analog Circuits I

B24EC2T03: Analog Circuits II

D B24EC1T03: Logic Circuit Design

### Course Outcomes

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                           |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Analyze and evaluate different CMOS amplifier configurations.                                                                                                             |
| <b>CO 2</b> | Design and analyze MOS current mirror and CMOS differential amplifier circuits with appropriate load configurations to achieve specified gain and impedance requirements. |
| <b>CO 3</b> | Apply the principles of op-amp performance analysis to evaluate single-stage and two-stage CMOS op-amps with different load conditions.                                   |
| <b>CO 4</b> | Analyze supply-independent biasing and temperature-independent bandgap reference circuits, and examine operating principles of switched capacitor.                        |
| <b>CO 5</b> | Analyze the non-idealities of DAC and ADC circuits and evaluate the operation and performance.                                                                            |

### Mapping of Course Outcomes With Program Outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 3    | 3    | 2    | 2    | 1    | 1    | 1    |      |       | 3     |
| <b>CO 2</b> | 3    | 3    | 3    | 2    | 2    | 1    | 1    | 1    |      |       | 3     |
| <b>CO 3</b> | 3    | 3    | 3    | 2    | 1    | 1    | 1    | 1    |      |       | 3     |
| <b>CO 4</b> | 3    | 3    | 3    | 2    | 2    | 1    | 1    | 1    |      |       | 3     |
| <b>CO 5</b> | 3    | 3    | 3    | 2    | 2    | 1    | 1    | 1    |      |       | 3     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 10                    | 10              | 10                                 |
| Understand       | 20                    | 20              | 20                                 |
| Apply            | 20                    | 20              | 70                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## **SYLLABUS**

### **MODULE 1**

#### **CMOS Amplifiers**

Active load: MOS resistor, MOS current source, diode connected MOS. CMOS Amplifiers: Common source amplifier with resistive and active loads, Common source amplifier with source degeneration, Common gate and Common drain amplifier (only voltage gain and input and output impedances of the circuits).

### **MODULE 2**

#### **MOS Current Mirror and CMOS Differential Amplifier**

MOS Current Mirror: Simple, Cascode and Wilson current mirror circuits.

CMOS Differential Amplifier: Differential Amplifier with resistive, current source, with current mirror and cascode loads(only voltage gain and input and output impedance of the circuits).

### **MODULE 3**

#### **CMOS Operational Amplifier**

Opamp Performance parameters, Single stage and two stage op-amps with different types of load. Gain Boosting in Opamp.

### **MODULE 4**

#### **References and Switched Capacitor Circuits**

References: Supply Independent Biasing, Temperature independent references– band gap reference.

Switched Capacitor Circuits: Switched capacitor resistor, Switched Capacitor Integrator, 1st order filter.

### **MODULE 5**

#### **Data Converters**

DAC: Non-idealities in DAC, Types: Resistive, Charge redistribution, Voltage Scaling, Cyclic and Pipelined. ADC: Non-idealities in ADC, Sample and Hold circuit, quantization errors, Types of ADC : Flash, two step, pipelined, successive approximation, Folding.

#### **Text Books**

1. Behzad Razavi, “Design of Analog CMOS Integrated Circuits”, McGraw-Hill, 2/e, 2002
2. Meyer Gray , Hurst, Lewis, “Analysis and Design of Analog Integrated Circuits”, 5th



Edition ,Wiley 2009

**Reference Books**

1. Phillip E. Allen, Douglas R. Holbery, CMOS Analog Circuit Design, Oxford, 2004.
2. Razavi B., Fundamentals of Microelectronics, Wiley student Edition 2014.
3. Baker, Li, Boyce, CMOS: Circuits Design, Layout and Simulation, PHI, 2000



**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                               | <b>No of Lecture/Tutorial Hours</b> |
|-----------|------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                            | <b>8</b>                            |
| 1.1       | MOS basics.                                                                                                | 1                                   |
| 1.2       | MOS resistor, MOS current source, diode connected MOS.                                                     | 2                                   |
| 1.3       | Common source amplifier with resistive and active loads, Common source amplifier with source degeneration. | 3                                   |
| 1.4       | Common gate amplifier.                                                                                     | 1                                   |
| 1.5       | Common drain amplifier..                                                                                   | 1                                   |
|           | <b>Module 2</b>                                                                                            | <b>6</b>                            |
| 2.1       | Simple current mirror, Cascode and Wilson current mirrors.                                                 | 1                                   |
| 2.2       | Differential Amplifier with resistive load.                                                                | 1                                   |
| 2.3       | Differential Amplifier with current source and current mirror loads.                                       | 2                                   |
| 2.4       | Differential Amplifier with cascode load.                                                                  | 2                                   |
|           | <b>Module 3</b>                                                                                            | <b>6</b>                            |
| 3.1       | Opamp Performance Parameters                                                                               | 1                                   |
| 3.2       | Single stage op-amp with resistive and active loads.                                                       | 2                                   |
| 3.3       | Two stage op-amp with resistive and active loads.                                                          | 2                                   |
| 3.4       | Gain Boosting in Opamp                                                                                     | 1                                   |
|           | <b>Module 4</b>                                                                                            | <b>6</b>                            |
| 4.1       | Supply Independent Biasing.                                                                                | 1                                   |
| 4.2       | Temperature independent reference- Negative and Positive T C Voltage                                       | 1                                   |
| 4.3       | Band gap reference.                                                                                        | 1                                   |
| 4.4       | Switched capacitor resistor, Switched Capacitor Integrator                                                 | 2                                   |
| 4.5       | 1st order filter.                                                                                          | 1                                   |
|           | <b>Module 5</b>                                                                                            | <b>9</b>                            |
| 5.1       | DAC non-idealities, Resistive DAC, Charge redistribution DAC.                                              | 1                                   |
| 5.2       | Voltage Scaling DAC, Cyclic and Pipelined DAC.                                                             | 2                                   |
| 5.3       | ADC non-idealities,                                                                                        | 1                                   |
| 5.4       | Sample and Hold circuit.                                                                                   | 1                                   |
| 5.5       | Quantization errors.                                                                                       | 1                                   |
| 5.5       | ADC Types:Flash, two step, pipelined, successive approximation, folding ADC                                | 3                                   |
|           | <b>Total Hours</b>                                                                                         | <b>35 Hours</b>                     |

## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1):**

1. Derive the voltage gain of a common source amplifier with a resistive load.
2. Compare MOS resistor and diode-connected MOS as active loads.

### **Course Outcome 2 (CO 2):**

1. Derive the voltage gain of a CMOS differential amplifier with resistive load.
2. Determine the input and output impedance of a differential amplifier with current source load.

### **Course Outcome 3 (CO 3):**

1. Explain how load capacitance affects bandwidth in a two-stage op-amp.
2. Determine the unity gain bandwidth of an op-amp given compensation capacitor value.

### **Course Outcome 4 (CO 4):**

1. Explain the need for supply-independent biasing in analog circuits.
2. Derive the condition for temperature independence in a bandgap reference.
3. Explain the working principle of a switched capacitor integrator.

### **Course Outcome 5 (CO 5):**

1. Explain quantization error in ADCs.
2. What is the function of a Sample and Hold circuit in ADC?

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2028**

**Course Code: B24EC4P34**

**Course Name: MIXED SIGNAL CIRCUIT DESIGN**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Write down the expression for drain current of an NMOS transistor in active and saturation regions.
2. Draw the small signal model of low frequency MOSFET.
3. State the significance of diode connected transistor in current mirror circuits.
4. Differentiate between cascade and cascode configurations.
5. What is the significance of tail current source in a differential amplifier?
6. What is the purpose of stage 1 and stage 2 amplifiers in a 2-stage op-amp?
7. What are the important parameters that are to be considered while designing reference circuits?
8. Derive the equivalent resistance of a series switched capacitor resistor.
9. Mention any two non-idealities of a DAC.
10. What is quantization error in an ADC?

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Draw the circuit diagram and derive the equivalent resistance of a MOS resistor. (4)  
b) Derive the voltage gain and output impedance of common source amplifier. (10)
12. a) Draw the circuit diagram and derive the equivalent resistance of a MOS current source. (4)  
b) Derive the voltage gain and output impedance of common gate amplifier. (10)

**Module II**

13. a) Derive the output impedance of simple current mirror (6)  
b) Derive the voltage gain and output impedance of Differential Amplifier with current source load. (8)
14. a) Derive the voltage gain and output impedance of Differential Amplifier with current mirror load. (14)

**Module III**

15. Draw the circuit diagram and derive the voltage gain and output impedance of a simple op-amp with cascade load. (14)
16. Draw the circuit diagram and derive the voltage gain and output impedance of a 2-stage op-amp with NMOS inputs. (14)

**Module IV**

17. a) Draw the circuit diagram and explain the working of supply independent biasing circuit (5)  
b) Draw the circuit diagram and derive the transfer function of parasitic sensitive switched capacitor integrator. (9)
18. a) Draw the circuit diagram and derive the transfer function of general 1st order switched capacitor filter. Also mention the circuits for high pass and low pass filters. (14)

**Module V**

19. a) Derive the expression for SNR of a DAC (5)  
b) Draw the circuit diagram and explain the working of pipeline DAC (9)
20. a) Explain INL and DNL errors in data converters. (5)  
b) Draw the circuit diagram and explain the working of successive approximation ADC (9)

| B24EC4P35 | RF CIRCUIT DESIGN | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|-------------------|---|---|---|---|--------|----------------------|
|           |                   | 2 | 1 | 0 | 4 | 3      | 2024                 |

### Preamble

This course provides an overview of fundamental aspects of RF technology, including the introduction to RF circuits, RF components, RF filter design, circuit measurements and characterization, and the modeling and simulation of RF circuits. Understanding these concepts is essential for designing reliable and high-performance RF systems used in various electronic and communication applications.

### Prerequisites

B24EC3T06 ELECTROMAGNETIC THEORY

### Course Outcomes

After the completion of the course, the student will be able to:

|      |                                                                                                                                        |
|------|----------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Understand the basic principles and operating concepts of Radio Frequency (RF) circuits used in communication systems.[Understand]     |
| CO 2 | Identify and explain the working of various RF components such as amplifiers, oscillators, mixers, and transmission lines.[Understand] |
| CO 3 | Design and analyze RF filters to achieve desired frequency response in RF communication systems.[Understand, Apply]                    |
| CO 4 | Perform circuit measurements and characterization using RF measurement techniques and instruments.[Understand, Apply]                  |
| CO 5 | Apply modeling and simulation techniques to analyze and optimize the performance of RF circuits.[Analyze, Apply]                       |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    |      |      |      |      | 2    |      |      |       |       |
| CO 2 | 3    | 2    |      |      |      |      | 2    |      | 1    |       |       |
| CO 3 | 2    | 3    | 3    | 1    |      |      | 1    |      |      |       |       |
| CO 4 | 2    | 3    | 1    | 2    | 2    |      |      |      | 1    |       |       |
| CO 5 | 2    | 2    | 2    | 1    | 3    |      |      |      |      |       |       |

### Assessment Pattern



| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         |                       |                 |                                    |
| Understand       | 80                    | 80              | 80                                 |
| Apply            |                       | 20              | 10                                 |
| Analyse          | 20                    |                 | 10                                 |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Introduction to RF circuits :** RF circuit introduction - Importance of radio frequency design, RF behavior of resistors, inductors, and capacitors. Introduction to S parameters. Transmission Lines-Equivalent Circuit representation-General Transmission Line Equation-Terminated transmission lines- Input impedance, Standing waves, VSWR, Return loss, Insertion loss, Characteristic impedance, Phase velocity. Planar Transmission Lines – Microstrip lines and Striplines – Constructional Features.

### MODULE 2

**RF Network Analysis :** Series and parallel resonant circuits, transmission line resonators. Single and Multi-port Networks– Definitions- Impedance matrix, Scattering matrix. Introduction to the Smith chart. Impedance Matching Networks - Design of Matching Circuits using Lumped Elements, Single Stub tuning, Quarter-Wave Transformers

### MODULE 3

**RF Components :** Diodes and detectors- Schottky and PIN diodes, Gunn diodes. Bipolar Junction Transistor – Construction, Functionality, Power. Frequency Limitations of High-Frequency Transistors. GaAs devices - Familiarization of RF Field Effect Transistors and High Electron Mobility Transistors–Construction details.

### MODULE 4

**RF Filter Design :** RF Filter Design- Filter Design using insertion loss technique. Stepped impedance design, Coupled line. Introduction to RF amplifiers, Stability Considerations – Stability Circles, Tests for Unconditional Stability.

### MODULE 5

**Circuit measurements and characterization :** Microwave bench- general measurement setup, Measurement devices and instrumentation- Slotted line, tunable detector, VSWR meter, power meter, wave meter, spectrum analyzer, Network analyzer, Test set-up for reflection transmission measurements, test set-up for S parameter measurements, Frequency measurement - electronic techniques, Measurements of power, Attenuation measurements, Measurements of VSWR, Measurements of impedance, Anechoic chamber. Modeling and Simulation of RF circuits using Open Source or Commercial EM Simulation Software.

### Text Books

1. Matthew M Radmanesh, Radio Frequency and Microwave electronics”, Pearson Educa-

tion Asia, 2001.

2. Vendalin, Microwave Circuit Design using Linear and Nonlinear Techniques, 2/e, Wiley, 2010
3. Ludwig, Reinhold. RF Circuit Design: Theory & Applications, 2/e. Pearson Education India, 2000.
4. Pozar, David M., Microwave and RF design of wireless systems. John Wiley & Sons, 2000
5. M. Kulkarni, Microwave and Radar Engineering. Umesh Publications, 1998

### **COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                        | <b>No of Lecture/Tutorial Hours</b> |
|-----------|---------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                                     | <b>12</b>                           |
| 1.1       | RF circuit introduction, Importance of radio frequency design, RF behavior of resistors, inductors, and capacitors. | 2                                   |
| 1.2       | Introduction to S parameters                                                                                        | 1                                   |
| 1.3       | Transmission Lines-Equivalent Circuit representation                                                                | 1                                   |
| 1.4       | General Transmission Line Equation- Terminated transmission lines- Input impedance, Standing waves                  | 2                                   |
| 1.5       | VSWR, Return loss, Insertion loss, Characteristic impedance, Phase velocity.                                        | 2                                   |
| 1.6       | Planar Transmission Lines – Microstrip lines and Striplines – Constructional Features.                              | 4                                   |
|           | <b>Module 2</b>                                                                                                     | <b>8</b>                            |
| 2.1       | Introduction: Series and parallel resonant circuits.                                                                | 2                                   |
| 2.2       | Single and Multi-port Networks– Definitions- Impedance matrix, Scattering matrix. Introduction to the Smith chart.  | 1                                   |
| 2.3       | Impedance Matching Networks - Design of Matching Circuits using Lumped Elements,                                    | 2                                   |
| 2.4       | Single Stub tuning, Quarter-Wave Transformers                                                                       | 3                                   |
|           | <b>Module 3</b>                                                                                                     | <b>8</b>                            |
| 3.1       | Diodes and detectors- Schottky and PIN diodes                                                                       | 2                                   |
| 3.1       | Gunn diodes                                                                                                         | 1                                   |
| 3.3       | Bipolar Junction Transistor – Construction, Functionality, Power.                                                   | 2                                   |
| 3.4       | Frequency Limitations of High- Frequency Transistors. GaAs devices                                                  | 1                                   |
| 3.5       | Familiarization of RF Field Effect Transistors and High Electron Mobility Transistors–Construction details.         | 2                                   |
|           | <b>Module 4</b>                                                                                                     | <b>9</b>                            |
| 4.1       | RF Filter Design- Filter Design using insertion loss technique                                                      | 4                                   |

|     |                                                                                                                                                                             |                 |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 4.2 | Stepped impedance design, Coupled line.                                                                                                                                     | 1               |
| 4.3 | Introduction to RF amplifiers                                                                                                                                               | 1               |
| 4.4 | Stability Considerations – Stability Circles,                                                                                                                               | 2               |
| 4.5 | Tests for Unconditional Stability                                                                                                                                           | 1               |
|     | <b>Module 5</b>                                                                                                                                                             | <b>7</b>        |
| 5.1 | Microwave bench- general measurement setup, Measurement devices and instrumentation- Slotted line, tunable detector, VSWR meter, power meter, wave meter, spectrum analyser | 2               |
| 5.2 | Network analyzer, Test set-up for reflection transmission measurements, test set-up for S parameter measurements                                                            | 2               |
| 5.3 | Frequency measurement - electronic techniques, Measurements of power, Attenuation measurements                                                                              | 1               |
| 5.4 | Measurements of VSWR, Measurements of impedance, Anechoic chamber.                                                                                                          | 1               |
| 5.5 | Modeling and Simulation of RF circuits using – Open source or Commercial EM Simulation Softwares.                                                                           | 1               |
|     | <b>Total Hours</b>                                                                                                                                                          | <b>44 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the high-frequency behavior of inductors
2. What do mean by characteristic impedance of a transmission line ? Give expressions.
3. Give the scattering matrix for a two-port network and define each element of the matrix.

#### Course Outcome 2 (CO 2):

1. Describe the construction and use of the Smith Chart for impedance calculations.
2. Explain the design of impedance matching circuits using lumped elements.
3. Explain the single stub tuning method for impedance matching.
4. Discuss the working and design of a quarter-wave transformer for impedance matching.

#### Course Outcome 3 (CO 3):

1. What is power handling capability in RF transistors?

2. What are frequency limitations of high-frequency transistors?
3. Explain transmission gate logic with circuit diagrams.
4. Explain the working principle and applications of Schottky diodes in RF circuits.
5. Describe the structure and operation of a PIN diode.

**Course Outcome 4 (CO 4):**

1. Explain the RF filter design using the insertion loss method with suitable diagrams.
2. Discuss the design and operation of stepped impedance filters.
3. Explain the construction and working of coupled line filters.
4. Describe the introduction, operation, and applications of RF amplifiers.

**Course Outcome 5 (CO 5):**

1. Explain the microwave bench setup and its components used for RF measurements.
2. Describe the working principles of measurement instruments such as VSWR meter, power meter, and wave meter.
3. Explain the operation and applications of spectrum analyzer and network analyzer.
4. Discuss the measurement of VSWR and impedance using a slotted line method.
5. Explain the methods used for attenuation and power measurements in microwave systems.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2029**

**Course Code: B24EC4P35**

**Course Name: RF CIRCUIT DESIGN**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. If the load impedance is not equal to the characteristic impedance, predict what happens to signal transmission in the line.
2. Given a microstrip line structure, explain how it can be used for RF signal transmission on PCBs.
3. An RF circuit requires high impedance at resonance. Determine whether a series or parallel resonant circuit should be used and justify.
4. Given a normalized impedance, apply the Smith chart to determine the corresponding reflection coefficient.
5. Explain the functionality of BJT in RF amplification.
6. Describe the construction features of GaAs devices used in RF circuits.
7. Explain the meaning of unconditional stability in RF amplifiers.
8. Apply the principle of coupled lines to explain how RF filters achieve frequency selectivity.
9. Explain the role of an anechoic chamber in RF testing.
10. Given an RF signal containing multiple frequencies, apply the spectrum analyzer to analyze the signal components.



**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. Derive the general transmission line equations and explain the equivalent circuit representation of a transmission line. (14)
12. Explain the formation of standing waves in transmission lines and derive the expressions for VSWR and reflection coefficient. (14)

**Module II**

13. Explain the working of transmission line resonators and discuss their importance in RF and microwave circuits. (14)
14. Explain scattering parameters (S-parameters) of a two-port network. Discuss the physical significance of  $S_{11}$ ,  $S_{12}$ ,  $S_{21}$ , and  $S_{22}$ . (14)

**Module III**

15. A microwave switching circuit requires low resistance in forward bias and high resistance in reverse bias. Apply the working principle of a PIN diode to design the RF switch and explain its operation. (14)
16. A microwave communication system requires devices with high electron mobility and low noise. Apply the properties of GaAs devices to justify their use. (14)

**Module IV**

17. Discuss the various steps involved in RF filter design using the insertion loss technique and explain the filter response characteristics. (14)
18. Explain the concept of stability circles and how they are used to determine amplifier stability. (14)

**Module V**

19. Explain the general measurement setup of a microwave bench with a neat diagram. Discuss the function of each component used in the setup. (14)
20. Explain the construction and working of a network analyzer and discuss its importance in RF circuit characterization. (14)

| B24EC4P41 | EMBEDDED NETWORKS | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|-------------------|---|---|---|---|--------|----------------------|
|           |                   | 2 | 1 | 0 | 4 | 3      | 2024                 |

### Preamble

The course is designed to provide students with a comprehensive understanding of networking principles tailored for resource-constrained embedded environments. It covers various communication layers, from low-level serial protocols to high-level industrial, automotive, and IoT standards

### Prerequisites

B24EC3T05 : Embedded Systems

B24EC2T02 : Computer Architecture and Microcontrollers

### Course Outcomes

After the completion of the course, the student will be able to:

|      |                                                                                                                                       |
|------|---------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Summarize embedded networking requirements and basic hardware interface mechanisms. [Understand, Comprehend]                          |
| CO 2 | Analyze local serial communication protocols like I2C, SPI, and USB in embedded architectures. [Analyze]                              |
| CO 3 | Illustrate the operational principles of automotive and industrial networking standards such as CAN and EtherCAT. [Understand, Apply] |
| CO 4 | Examine the implementation of lightweight TCP/IP stacks and Ethernet interfaces for embedded targets. [Analyze]                       |
| CO 5 | Design wireless IoT networking solutions using protocols like BLE, LoRaWAN, and MQTT for remote sensing. [Understand, Apply]          |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    |      | 1    |      |      |      |      |      |       | 3     |
| CO 2 | 3    | 3    | 2    |      | 1    | 2    |      |      |      |       | 3     |
| CO 3 | 3    | 3    | 3    |      | 3    | 3    |      |      |      |       | 3     |
| CO 4 | 3    | 2    | 3    | 2    | 2    |      |      |      |      |       | 3     |
| CO 5 | 3    | 3    | 2    | 3    | 2    | 3    | 2    | 1    |      |       | 3     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 30                    | 30                 | 30                                    |
| Apply            | 50                    | 50                 | 50                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## **SYLLABUS**

### **MODULE 1**

**Introduction to Embedded Networking:** Embedded systems vs. General-purpose networking; Requirements for embedded networks (determinism, latency, power consumption), Serial vs. Parallel communication; Synchronous vs. Asynchronous transfers.

Architecture: The OSI Reference Model in the context of embedded systems; Data Encapsulation and Framing.

UART: Frame format, baud rate synchronization, and error detection. RS232, RS485.

Self-Study: Identify transceivers for UART communication. Design an UART interface for long-distance communication.

### **MODULE 2**

**Local Serial Communication Protocols:** I2C (Inter-Integrated Circuit): Multi-master/multi-slave architecture, arbitration, clock stretching, and 7-bit/10-bit addressing.

SPI (Serial Peripheral Interface): Four-wire synchronous communication, clock polarity (CPOL) and phase (CPHA) configurations.

USB for Embedded: Physical layer, descriptors, and enumeration process.

Self-Study: Compare I2C and SPI for embedded networking applications. Design a network to interface multiple sensors to an embedded system. Study the limitations and prescribe an embedded network for high-throughput data transfer.

### **MODULE 3**

**Automotive and Industrial Networking:** CAN (Controller Area Network): CAN Message frames,; Bit-wise arbitration and identifier priority; Error handling and fault confinement.

Advanced Protocols: Overview of Field bus and EtherCAT. Introduction to FlexRay (time-triggered) and Automotive Ethernet.

Self-Study: Implementing a basic CAN node using a microcontroller (e.g., STM32 or PIC).

### **MODULE 4**

**Embedded Ethernet and TCP/IP:** Embedded Ethernet: Physical layer (PHY) and Media Access Control (MAC); MII/RMII interfaces.

TCP/IP Lean: Implementing a reduced TCP/IP stack; Address Resolution Protocol (ARP); IP datagrams.

Transport Layer: User Datagram Protocol (UDP) vs. Transmission Control Protocol (TCP) in embedded constraints.

Self-Study: IP addressing, subnetting, network masking.

## **MODULE 5**

**Wireless Embedded Networking and IoT:** Short Range: Bluetooth, Bluetooth Low Energy (BLE) – Advertising and GATT profiles;

Long Range: Introduction to LoRaWAN and NB-IoT for remote sensing.

Application Layer Protocols: MQTT and CoAP for resource-constrained devices.

Self-Study: Security challenges in wireless embedded networks (Encryption and Authentication), Networking Examples - Home Automation. Block diagram, schematic, and remote control using IoT.

### **Text Books**

1. Frank Vahid and Tony Givargis, Embedded System Design: A Unified Hardware/Software Introduction, 3rd Ed., John Wiley & Sons.
2. Olaf Pfeiffer, Andrew Ayre, and Christian Keydel, Embedded Networking with CAN and CANopen, RTC Books.
3. Jeremy Bentham, TCP/IP Lean: Web Servers for Embedded Systems, 2nd Ed., CMP Books.
4. Wolfhard Lawrenz, CAN System Engineering: From Theory to Practical Applications, Springer-Verlag.
5. Holger Karl and Andreas Willig, Protocols and Architectures for Wireless Sensor Networks, Wiley.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                                                                                         | <b>No of Lecture/Tutorial Hours</b> |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                                                                                                      | <b>6</b>                            |
| 1.1       | Embedded vs. General-purpose networking; Requirements: determinism, latency, power.                                                                                                  | 2                                   |
| 1.2       | Serial vs. Parallel communication; Synchronous vs. Asynchronous transfers; Architecture: The OSI Reference Model in the context of embedded systems; Data Encapsulation and Framing. | 2                                   |
| 1.3       | UART Frame format, baud rate sync, error detection; RS232, RS485.                                                                                                                    | 2                                   |
|           | <b>Module 2</b>                                                                                                                                                                      | <b>9</b>                            |
| 2.1       | Local Serial Communication Protocols: I2C (Inter-Integrated Circuit): Multi-master/multi-slave architecture, arbitration, clock stretching                                           | 3                                   |
| 2.2       | I2C: 7-bit/10-bit addressing; Sensor networking designs.                                                                                                                             | 2                                   |
| 2.3       | SPI (Serial Peripheral Interface): Four-wire synchronous communication, clock polarity (CPOL) and phase (CPHA) configurations.                                                       | 2                                   |
| 2.4       | USB for Embedded: Physical layer, descriptors, and enumeration process.                                                                                                              | 2                                   |
|           | <b>Module 3</b>                                                                                                                                                                      | <b>9</b>                            |
| 3.1       | USB for Embedded: Physical layer, descriptors, and enumeration process.                                                                                                              | 3                                   |
| 3.2       | TCP/IP Lean: Implementing a reduced TCP/IP stack; Address Resolution Protocol (ARP); IP datagrams.                                                                                   | 3                                   |
| 3.3       | Advanced Protocols: Overview of Field bus and EtherCAT.                                                                                                                              | 2                                   |
| 3.4       | Introduction to FlexRay (time-triggered) and Automotive Ethernet. .                                                                                                                  | 2                                   |
|           | <b>Module 4</b>                                                                                                                                                                      | <b>9</b>                            |
| 4.1       | Embedded Ethernet: Physical layer (PHY) and Media Access Control (MAC); MII/RMII interfaces.                                                                                         | 2                                   |
| 4.2       | TCP/IP Lean: Implementing a reduced TCP/IP stack; Address Resolution Protocol (ARP); IP datagrams.                                                                                   | 3                                   |
| 4.3       | Transport Layer: User Datagram Protocol (UDP) vs. Transmission Control Protocol (TCP) in embedded constraints.                                                                       | 3                                   |
|           | <b>Module 5</b>                                                                                                                                                                      | <b>7</b>                            |
| 5.1       | Short Range: Bluetooth, Bluetooth Low Energy (BLE) – Advertising and GATT profiles.                                                                                                  | 2                                   |
| 5.2       | Long Range: Introduction to LoRaWAN and NB-IoT for remote sensing.                                                                                                                   | 3                                   |



|     |                                                                                |                 |
|-----|--------------------------------------------------------------------------------|-----------------|
| 5.3 | Application Layer Protocols: MQTT and CoAP for resource-constrained devices. . | 2               |
|     | <b>Total Hours</b>                                                             | <b>40 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the concept of "Determinism" in embedded networks. Why is it more critical in a flight control system than in a standard office LAN?.
2. Compare RS232 and RS485 in terms of distance, data rate, and noise immunity. Which is better suited for an industrial plant floor?

#### Course Outcome 2 (CO 2):

1. During I2C communication, two masters pull the SDA line low at different times. Explain the step-by-step process of Arbitration.
2. Design a connection diagram and explain the register settings required to interface a high-speed 16-bit ADC to a microcontroller using SPI Mode 3.

#### Course Outcome 3 (CO 3):

1. In a CAN network, calculate the priority of two messages with Identifiers 0x3FF and 0x001. Which wins arbitration and why?
2. Contrast the "Time-Triggered" nature of FlexRay with the "Event-Triggered" nature of standard CAN.

#### Course Outcome 4 (CO 4):

1. Illustrate the header structure of a "Lean" IP datagram. How is it optimized to save memory in an 8-bit microcontroller?
2. Explain the hardware signal mapping for RMII (Reduced Media Independent Interface). How many pins are saved compared to standard MII?

#### Course Outcome 5 (CO 5):

1. Propose an MQTT-based system architecture for a smart irrigation system where 50 moisture sensors must report to a central dashboard.
2. Describe the GATT Profile hierarchy (Service -> Characteristic -> Value) used to send heart rate data from a wearable to a smartphone.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2028**

**Course Code: B24EC4P41**

**Course Name: Embedded Networks**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. What is "Latency Jitter" and how does it affect real-time control?
2. Sketch the frame format of a standard UART packet with parity.
3. Why is I2C called a "Two-Wire" interface? Name the lines.
4. Define CPOL and CPHA in the context of SPI.
5. What is the purpose of the "Acknowledgment Slot" in a CAN frame?
6. Briefly explain the "Processing on the Fly" concept in EtherCAT.
7. Distinguish between the PHY and MAC layers in Embedded Ethernet.
8. Why is ARP (Address Resolution Protocol) necessary in a local network?.
9. List three differences between LoRaWAN and NB-IoT.
10. Define "Quality of Service" (QoS) levels in MQTT.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain the OSI Reference Model and discuss how layers are often collapsed in embedded networking to reduce overhead. (10)  
b) Compare Synchronous and Asynchronous data transfers. (4)
12. a) Discuss the hardware requirements and frame structure of RS485. Explain its multi-drop capability. (8)  
b) Describe the role of Data Encapsulation and Framing in embedded communication. (6)

**Module II**

13. a) Analyze the I2C Clock Stretching mechanism. How does a slave device use this to slow down a master? (8)  
b) Describe the USB Enumeration process from the moment a device is plugged in. (6)
14. a) Design a multi-sensor system using SPI. Explain how the Master uses Slave Select (SS) lines to manage multiple devices. (10)  
b) Explain the 7-bit addressing format in I2C. (4)

**Module III**

15. a) Explain the CAN Bit-wise Arbitration process in detail. How does it ensure that the highest priority message is never delayed? (10)  
b) Briefly describe the architecture of Automotive Ethernet. (4)
16. a) Discuss the CAN Error Handling states: Error Active, Error Passive, and Bus Off. (8)  
b) Explain the frame structure of a LIN (Local Interconnect Network) message. (6)

**Module IV**

17. a) Describe the implementation of a Lean TCP/IP stack. How is it different from a standard workstation stack? (10)  
b) Explain the difference between UDP and TCP in terms of reliability vs. speed for embedded targets. (4)
18. a) Discuss the hardware interface between the MAC and PHY using the MII and RMI standards. (8)  
b) Explain how IP Addressing and Subnetting work in a small-scale embedded network. (6)

**Module V**

19. a) Analyze the MQTT Publish/Subscribe architecture. Explain how the Broker manages messages between clients. (8)

- b) Discuss the Advertising and Connection modes in Bluetooth Low Energy (BLE).  
(6)
- 20. a) Describe the CoAP (Constrained Application Protocol) and explain why it is often used with UDP for IoT. (8)
- b) Discuss the major Security Challenges (Encryption/Authentication) in wireless embedded networks. (6)



| B24EC4P42 | MICROWAVE<br>AND ANTENNAS | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|---------------------------|---|---|---|---|--------|-------------------------|
|           |                           | 2 | 1 | 0 | 4 |        |                         |

### Preamble

This course introduces the fundamental principles of microwave engineering and antenna systems used in modern communication systems. It provides knowledge of microwave devices, components, measurements, and antenna design techniques essential for understanding high-frequency communication systems.

### Prerequisites

ELECTROMAGNETICS

### Course Outcomes

After the completion of the course, the student will be able to:

|      |                                                                                                                                                                                          |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Explain the microwave frequency range, applications, and the working principles of microwave tubes such as klystron, magnetron, and traveling wave tube. [Understand, Remember]          |
| CO 2 | Describe microwave transmission line concepts, scattering parameters, and the operation of microwave junctions and components. [Understand]                                              |
| CO 3 | Explain the characteristics and working principles of microwave semiconductor devices and basic microwave measurement techniques. [Understand]                                           |
| CO 4 | Calculate antenna parameters such as gain, directivity, beamwidth, radiation resistance, and analyze radiation characteristics of basic antennas. [Understand, Apply]                    |
| CO 5 | Apply antenna array principles and explain the operation and design concepts of antennas such as Yagi-Uda, microstrip patch, horn, and parabolic reflector antennas. [Understand, Apply] |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    | 1    | 1    | 1    | 1    |      | 1    |      |       | 2     |
| CO 2 | 3    | 2    | 1    | 1    | 1    | 1    | 1    |      |      |       | 2     |
| CO 3 | 3    | 3    | 1    | 1    | 1    |      |      |      | 1    | 1     | 2     |
| CO 4 | 3    | 2    | 2    | 2    | 1    |      |      |      |      |       | 2     |
| CO 5 | 3    | 3    | 3    | 2    | 2    |      | 1    | 1    | 1    | 2     | 2     |



### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 10                    | 10                 | 10                                    |
| Understand       | 80                    | 80                 | 80                                    |
| Apply            | 10                    | 10                 | 10                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Microwave Devices and Vacuum Tube Amplifiers:** Microwave frequency range and applications, Need for microwave devices, classification of microwave tubes, klystron amplifier –two cavity and reflex klystron (principle and operation only ), magnetron – construction, operation and modes, traveling wave tube (TWT) – principle and amplification.

### MODULE 2

**Microwave Transmission Lines and Passive Components :** Microwave transmission line basics, scattering parameters, microwave junctions – E-plane tee, H-plane tee, magic tee, directional couplers, circulators and isolators .

### MODULE 3

**Microwave Semiconductor Devices and Measurements :** Introduction to microwave semiconductor devices- Diodes: Varactor, Tunnel, Gunn ,IMPATT. Transistor: MESFET, BJT. Microwave measurements: VSWR, Frequency, Impedance

### MODULE 4

**Antenna Fundamentals and Basic Radiating Structures :** Introduction to antennas, radiation mechanism, antenna parameters –gain, directivity, beam width and effective aperture calculations, effective height, wave polarization, radiation resistance, radiation efficiency, antenna field zones. Duality and Principles of reciprocity, Helmholtz theorem. Field, directivity and radiation resistance of a short dipole and half wave dipole (no derivation needed)

### MODULE 5

**Antenna Arrays and Advanced Antenna Systems:** Antenna arrays – broadside and end-fire arrays, pattern multiplication, Yagi-Uda antenna, Design of Microstrip Rectangular Patch antennas and feeding methods , Principles of Horn, Parabolic dish antenna (expression for E, H and Gain without derivation), introduction to phased array and smart antennas.

### Text Books

- 1.Balanis, Antenna Theory and Design, 3/e, Wiley Publications.
- 2.John D. Krauss, Antennas for all Applications, 3/e, TMH
- 3.K D Prasad, Antenna and Wave Propagation, Satyaprakash Publications
4. Das, Microwave Engineering, 3/e, McGraw Hill Education India Education , 2014
5. David M. Pozar, Microwave Engineering,4/e, Wiley India, 2012.
6. S.V. Kulkarni – Microwave and Radar Engineering, Umesh Publications / Technical Publications.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                              | <b>No of Lecture/Tutorial Hours</b> |
|-----------|-----------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                           | <b>6</b>                            |
| 1.1       | Microwave frequency range, applications, need for microwave devices .                                     | 1                                   |
| 1.2       | Classification of microwave tubes, Two cavity klystron amplifier – principle and operation.               | 2                                   |
| 1.3       | Reflex klystron – construction and operation                                                              | 1                                   |
| 1.4       | Magnetron – construction, operation and modes                                                             | 1                                   |
| 1.5       | Traveling Wave Tube (TWT) – principle and amplification                                                   | 1                                   |
| 1.6       |                                                                                                           | 1                                   |
|           | <b>Module 2</b>                                                                                           | <b>6</b>                            |
| 2.1       | Microwave transmission line basics, scattering parameters                                                 | 1                                   |
| 2.2       | Microwave junctions – E-plane tee, H-plane tee                                                            | 2                                   |
| 2.3       | Magic tee, directional couplers                                                                           | 2                                   |
| 2.4       | Circulators, isolators                                                                                    | 1                                   |
|           | <b>Module 3</b>                                                                                           | <b>7</b>                            |
| 3.1       | Microwave semiconductor devices – Varactor, Tunnel diodes                                                 | 2                                   |
| 3.2       | Gunn diode, IMPATT diode.                                                                                 | 1                                   |
| 3.3       | Microwave transistors – MESFET, BJT                                                                       | 1                                   |
| 3.4       | Microwave measurements – VSWR, frequency and impedance measurements                                       | 3                                   |
|           | <b>Module 4</b>                                                                                           | <b>8</b>                            |
| 4.1       | Introduction to antennas, radiation mechanism                                                             | 2                                   |
| 4.2       | Antenna parameters – gain, directivity, beam width, effective aperture                                    | 1                                   |
| 4.3       | Radiation resistance, radiation efficiency, Polarization, antenna field zones                             | 1                                   |
| 4.4       | Duality and Principles of reciprocity, Helmholtz theorem.                                                 | 1                                   |
| 4.5       | Field, directivity and radiation resistance of a short dipole and half wave dipole (no derivation needed) | 3                                   |
|           | <b>Module 5</b>                                                                                           | <b>9</b>                            |
| 5.1       | Antenna arrays – broadside and end-fire arrays, pattern multiplication                                    | 3                                   |
| 5.2       | Yagi-Uda antenna, Microstrip rectangular patch antenna                                                    | 3                                   |
| 5.3       | Horn antenna, Parabolic dish antenna,                                                                     | 1                                   |
| 5.4       | introduction to phased array and smart antennas                                                           | 2                                   |
|           | <b>Total Hours</b>                                                                                        | <b>36 Hours</b>                     |

## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1):**

1. State the function of buncher cavity in a klystron.
2. Explain the principle of velocity modulation in klystron.
3. Describe the construction and working of reflex klystron.

### **Course Outcome 2 (CO 2):**

1. Define scattering parameters.
2. Explain the working of E-plane tee and H-plane tee.
3. Describe the operation of directional coupler.

### **Course Outcome 3 (CO 3):**

1. List different microwave semiconductor diodes.
2. Explain the working principle of Gunn diode.
3. Describe frequency measurement in microwave systems.

### **Course Outcome 4 (CO 4):**

1. Define radiation resistance.
2. Explain the radiation mechanism of antennas.
3. Describe antenna field regions.

### **Course Outcome 5 (CO 5):**

1. Explain the concept of pattern multiplication.
2. Determine the radiation pattern of a simple antenna array.
3. Apply basic design concepts of microstrip patch antenna.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24EC4P42**

**Course Name: MICROWAVE AND ANTENNAS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define microwave frequency range and give two applications.
2. What is velocity modulation in klystron?
3. Define scattering parameters.
4. What is an E-plane tee?
5. Define VSWR.
6. What is Gunn diode?
7. Define antenna gain.
8. What is radiation resistance?
9. Define broadside array.
10. What is pattern multiplication?

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

- 11. a) Explain the working principle of two cavity klystron amplifier. (7)  
b) Describe the construction and operation of magnetron. (7)
- 12. a) Explain the operation of reflex klystron. (7)  
b) Explain the working principle of traveling wave tube. (7)

**Module II**

- 13. a) Explain the working of E-plane tee and H-plane tee. (7)  
b) Describe the working principle of directional coupler. (7)
- 14. a) Explain the working of magic tee. (7)  
b) Describe the **operation of circulator and isolator.** (7)

**Module III**

- 15. a) Explain the working principle of tunnel diode. (7)  
b) Describe microwave impedance measurement methods. (7)
- 16. a) Explain the operation of Gunn diode and IMPATT diode. (7)  
b) Explain frequency measurement in microwave systems. (7)

**Module IV**

- 17. a) Explain radiation mechanism of antennas. (7)  
b) Calculate antenna directivity and gain for given data. (7)
- 18. a) Explain antenna field regions. (7)  
b) Describe radiation resistance and radiation efficiency. (7)

**Module V**

- 19. a) Explain broadside and end-fire antenna arrays. (7)  
b) Explain pattern multiplication principle. (7)
- 20. a) Describe the working of Yagi-Uda antenna. (7)  
b) Explain the construction and working of parabolic reflector antenna. (7)



| B24EC4P43 | SECURE COMMUNICATION | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|----------------------|---|---|---|---|--------|----------------------|
|           |                      | 2 | 1 | 0 | 4 | 3      | 2024                 |

**Preamble**

This course aims to provide an insight into the theory and technology behind secure communication.

**Prerequisites**

Nil

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                 |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Explain network security services and mechanisms and the types of attacks they are designed for. [Understand,Apply]                             |
| <b>CO 2</b> | Model the symmetric encryption process and different encryption techniques. [Understand, Apply]                                                 |
| <b>CO 3</b> | Apply the concepts of group, ring, field, modular arithmetic, Euclidean algorithm, Finite fields and polynomial arithmetic. [Understand, Apply] |
| <b>CO 4</b> | Illustrate the principles of modern symmetric ciphers like the Data Encryption Standard and Advanced Encryption Standard. [Understand, Apply]   |
| <b>CO 5</b> | Outline the concepts of public key cryptography, RSA algorithm, key distribution and management for public key systems. [Understand, Apply]     |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 3    | 2    |      |      | 1    |      |      |      |       | 2     |
| <b>CO 2</b> | 3    | 3    |      | 1    |      | 1    |      | 1    |      |       | 2     |
| <b>CO 3</b> | 3    | 3    |      |      | 1    | 1    | 1    |      | 1    |       | 2     |
| <b>CO 4</b> | 3    | 3    |      |      |      | 1    | 1    |      |      | 1     | 2     |
| <b>CO 5</b> | 3    | 3    |      |      |      | 1    |      |      | 1    |       | 2     |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Introduction and Classic Encryption Techniques** OSI security architecture, Security attacks – Passive attacks, Active attacks, Security services- Authentication, Access Control, Data Confidentiality, Data integrity, Nonrepudiation, Availability service. Model for network security. Symmetric cipher model, Cryptography, Cryptoanalysis, Substitution techniques- Hill Cipher, One time pad, Transposition Techniques.

### MODULE 2

**Finite Fields** Groups, Rings and Fields, Modular arithmetic, Euclidian algorithm, Finite Fields of the form  $GF(p)$ , Polynomial arithmetic.

### MODULE 3

**Block Ciphers. Data Encryption Standard, AES Cipher:** Block Cipher Principles – Stream Ciphers and Block Ciphers, Feistel Cipher, Feistel Decryption algorithm, The Data encryption standard, DES Decryption - Avalanche effect, The AES Cipher, substitute bytes transformation, Shift row transformation, Mix Column transformation.

### MODULE 4 Public Key Cryptography, RSA and Key Management:

Principles of public key cryptosystems-Public key cryptosystems, Application for Public key cryptosystem requirements, Fermat's theorem, Euler's Totient Function, Euler's theorem, RSA algorithm, Key management, Distribution of public keys, Publicly available directory, Public key authority, public key certificates, Distribution of secret keys using public key cryptography.

### MODULE 5

**Message Authentication and Hash Function:** Authentication requirements, Authentication functions- Message Encryption, Public Key Encryption, Message Authentication Code, Hash function.

### Text Books

1. William Stallings, Cryptography and Network security: principles and practice, 4th Edition, Prentice Hall of India, New Delhi, 2006
2. Behrouz A. Forouzan, Cryptography and Network security Tata McGraw-Hill, 2008
3. David S. Dummit & Richard M Foote, Abstract Algebra, 2nd Edition, Wiley India Pvt. Ltd., 2008

4. Douglas A. Stinson, Cryptography, Theory and Practice, 2/e, Chapman & Hall, CRC Press Company, Washington, 2005.
5. Lawrence C. Washington, Elliptic Curves: Theory and Cryptography, Chapman & Hall, CRC Press Company, Washington, 2008.
6. N. Koblitz: A course in Number theory and Cryptography, 2008
7. Thomas Koshy: Elementary Number Theory with Applications, 2/e, Academic Press, 2007
8. Tyagi and Yadav, Cryptography and network security, Dhanpatrai, 2012



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                                                | No of Lecture/Tutorial Hours |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                                                      | <b>8</b>                     |
| 1.1 | OSI system architecture, Security attacks – Passive attacks, Active attacks                                                                                                          | 1                            |
| 1.2 | Security services- Authentication, Access Control, Data Confidentiality, Data integrity, Nonrepudiation, Availability service. Security Mechanisms                                   | 2                            |
| 1.3 | A model for network security                                                                                                                                                         | 1                            |
| 1.4 | Symmetric cipher model, Cryptography, Cryptoanalysis.                                                                                                                                | 1                            |
| 1.5 | Substitution techniques- Hill Cipher, One time pad.                                                                                                                                  | 2                            |
| 1.6 | Transposition Techniques.                                                                                                                                                            | 1                            |
|     | <b>Module 2</b>                                                                                                                                                                      | <b>8</b>                     |
| 2.1 | Groups, Rings and Fields                                                                                                                                                             | 1                            |
| 2.2 | Modular arithmetic.                                                                                                                                                                  | 2                            |
| 2.3 | Euclidian algorithm                                                                                                                                                                  | 1                            |
| 2.4 | Finite Fields of the form $GF(p)$                                                                                                                                                    | 2                            |
| 2.5 | Polynomial arithmetic                                                                                                                                                                | 2                            |
|     | <b>Module 3</b>                                                                                                                                                                      | <b>9</b>                     |
| 3.1 | Block Cipher Principles – Stream Ciphers and Block Ciphers, Feistel Cipher, Feistel Decryption algorithm                                                                             | 2                            |
| 3.2 | The Data encryption standard, DES Decryption – The Avalanche effect                                                                                                                  | 3                            |
| 3.3 | The AES Cipher, substitute bytes transformation, Shift row transformation, Mix Column transformation                                                                                 | 4                            |
|     | <b>Module 4</b>                                                                                                                                                                      | <b>7</b>                     |
| 4.1 | Principles of public key cryptosystems-Public key cryptosystems, Application for Public key cryptosystem requirements.                                                               | 2                            |
| 4.2 | Fermat's theorem, Euler's Totient Function, Euler's theorem, RSA algorithm- Description of the algorithm                                                                             | 3                            |
| 4.3 | Key management, Distribution of public keys, Publicly available directory, Public key authority, public key certificates, Distribution of secret keys using public key cryptography. | 2                            |
|     | <b>Module 5</b>                                                                                                                                                                      | <b>8</b>                     |
| 5.1 | Authentication requirements, Authentication functions- Message Encryption, Public Key Encryption, Message Authentication Code, Hash function.                                        | 3                            |
|     | <b>Total Hours</b>                                                                                                                                                                   | <b>35 Hours</b>              |

## **CO ASSESSMENT QUESTIONS**

**Course Outcome 1 (CO 1): Explain network security services and mechanisms and the types of attacks they are designed for.**

1. Describe the OSI security architecture.
2. Differentiate between active and passive security threats.
3. Define the categories of security services and security threats

**Course Outcome 2 (CO 2): Explain the general model for the symmetric encryption process and some of the encryption techniques in use.**

1. Describe the five ingredients in a symmetric cipher model.
2. Encrypt and decrypt plaintext using Hill cipher.
3. Describe one time pad.

**Course Outcome 3 (CO 3): Apply the concepts of group, ring, field, modular arithmetic, Euclidean algorithm, Finite fields and polynomial arithmetic**

1. Define a group, ring and field.
2. Determine the gcd of 2 given numbers.
3. Find the multiplicative inverse using extended Euclidean algorithm.

**Course Outcome 4 (CO 4): Illustrate the principles of modern symmetric ciphers like the Data Encryption Standard and Advanced Encryption Standard**

1. Explain avalanche effect.
2. Describe the DES encryption algorithm.
3. Describe ShiftRows transformation in AES

**Course Outcome 5 (CO 5): Describe the requirements for authentication and the types of functions that may be used to produce an authenticator**

1. What types of attacks are addressed by message authentication?
2. Explain the basic uses of message encryption.
3. Explain the basic uses of Message Authentication Code.



MODEL QUESTION PAPER

QP CODE:

Pages: 5

Reg.No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, NOV 2027

Course Code: B24EC4P43

Course Name: SECURE COMMUNICATION

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Illustrate the categories of active attacks.
2. Express Hill Cipher system in general terms. Describe the strength of the Hill Cipher.
3. Determine whether the set of residue class modulo 3 forms a group with respect to addition.
4. Determine the multiplicative inverse of each non zero element in  $Z_5$ .
5. Differentiate between diffusion and confusion.
6. Differentiate between block cipher and stream cipher.
7. State and prove Fermat's theorem.
8. Explain the requirements for public key cryptography.
9. Define the types of attacks which can be addressed by message authentication.
10. Define the 3 classes of functions which can be used to produce an authenticator.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Describe specific and pervasive security mechanisms. (7)  
b) Decrypt the following message that was encrypted by using a railfence cipher with 4 rails.  
TTTPT QDSYP RSHII XEDOH EIUNS ESLDY TEMES SERSE NELSC NEAUC  
FLERE GAMAE BHDII SCUDD NG (7)

12. a) Describe a symmetric cipher model. (7)  
b) Encrypt the message: "payransom" using Hill Cipher with the key  $\begin{bmatrix} 5 & 1 \\ 2 & 7 \end{bmatrix}$ . (7)

**Module II**

13. a) Define a field. (7)  
b) Find the gcd (24140, 16762) (7)  
14. a) Using the extended Euclidean algorithm, find the multiplicative inverse of 1234 mod 4321 (7)  
b) Calculate using coefficients in  $Z_{10}$   
i.  $(7x + 2) - (x^2 + 5)$   
ii.  $(6x^2 + x + 3)x(5x^2 + 2)$  (7)

**Module III**

15. a) Describe the internal structure of a single round of DES Encryption algorithm (8)  
b) In an AES system, given the plain text {000102030405060708090A0B0C0D0E0F} and the key {01010101010101010101010101010101},  
i. Show the original contents of State, displayed as a 4x4 matrix.  
ii. Show the value of State after initial Add Round Key  
Describe the characteristics of the AES Cipher (6)  
16. What are the parameters and design choices that determine the actual algorithm of a Feistel Cipher. Describe Feistel Encryption and Decryption. (14)

**Module IV**

17. (a) State and prove Euler's theorem. (6)  
(b) Using Fermat's Theorem, find (i)  $3^{201} \bmod 11$  (ii) a number  $a$  between 0 and 72 with  $a$  congruent to 9794 modulo 73. (8)  
18. (a) Describe the essential elements of a public key cryptosystem scheme (7)  
(b) Perform encryption and decryption using RSA algorithm for  $p = 3$ ,  $q = 11$ ,  $e = 7$ ,  $M = 5$ . (7)

**Module V**

19. Describe a hash function. Illustrate the different ways in which hash function can be used to provide message authentication. Describe the confidentiality and authentication implications of the different approaches. (14)
20. (a) Illustrate the basic uses of message encryption. (7)
- (b) Explain authentication using message authentication code (7)



| B24EC4P44 | ANALOG CMOS DESIGN | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|--------------------|---|---|---|---|--------|----------------------|
|           |                    | 2 | 1 | 0 | 4 |        |                      |

### Preamble

This course aims to impart the basic knowledge of CMOS analog circuit design and enable students to design integrated circuits.

### Prerequisites

B24EC2T03 : ANALOG CIRCUITS 2  
B24EC2T04 : SOLID STATE DEVICES

### Course Outcomes

After completion of the course, the student will be able to:

|      |                                                                                                                                                                            |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Explain the basic MOS device characteristics, second-order effects, and the operation of simple and cascode current mirrors. [Understand]                                  |
| CO 2 | Apply the concepts of single-stage MOS amplifiers and differential amplifier circuits to evaluate their behavior under various load conditions. [Apply]                    |
| CO 3 | Explain the operation of MOSFET voltage dividers and different self-biasing and voltage reference circuits used in analog integrated circuits. [Understand]                |
| CO 4 | Illustrate the principles and applications of switched capacitor circuits, including sample-and-hold circuits, switched capacitor resistors, and integrators. [Understand] |
| CO 5 | Outline the working of Phase Locked Loops (PLL), their basic components, and applications in frequency synthesis and multiplication. [Understand]                          |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    |      |      | 1    |      |      |      |      |       | 1     |
| CO 2 | 3    | 3    | 2    | 2    | 2    |      |      |      |      |       | 1     |
| CO 3 | 3    | 2    |      |      | 1    |      |      |      |      |       | 1     |
| CO 4 | 3    | 2    | 1    |      | 2    |      |      |      |      |       | 1     |
| CO 5 | 3    | 2    | 1    |      | 2    |      |      |      |      |       | 1     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 10                    | 10              | 10                                 |
| Understand       | 20                    | 20              | 60                                 |
| Apply            | 10                    | 10              | 30                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Quiz/Course project         | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have a maximum of 2 sub-divisions.

### Simulation Assignments:

At least one assignment should be the simulation of the circuits. Simulations can be done in QUCS, KiCad or PSPICE or LT Spice or CADENCE.

## **SYLLABUS**

### **MODULE 1**

**Basic MOS Device physics:** Review of MOS Characteristics and Second order effects(only basic theoretical concepts).

**Current Mirror:** Simple, Cascode and Basic concepts of active current Mirror.

### **MODULE 2**

**Single Stage Amplifiers:** Common Source Stage with Different Load types , Source Follower, Common Gate and Cascode Stage).

**Differential Amplifiers:** Single-ended and differential operation, Basic differential pair, Common-mode response, Differential pair with MOS load, Gilbert Cell.

### **MODULE 3**

**Voltage Dividers:** Resistor MOSFET divider, MOSFET only voltage divider.

**Current Source Self Biasing:** Threshold voltage referenced self-biasing, Diode referenced self-biasing, Thermal voltage referenced self-biasing.

**Bandgap Voltage References:** Bandgap referenced biasing.

**Beta Multiplier Referenced Self Biasing:** A Voltage Reference, Operation in the sub-threshold region.

### **MODULE 4**

**Switched Capacitor Circuits:** Introduction to Switched Capacitor Circuits, Sample and hold circuit, Switched Capacitor Resistor (different types), Switched Capacitor Integrator (different types), Advantages of Switched Capacitor Circuits, Limitations, Applications.

### **MODULE 5**

**Phase Locked Loops:** Mathematical model of VCO, Phase Detector, Basic PLL Topology, Type I and Type II(Charge Pump) PLL, Stability Analysis of PLL, Non Ideal Effects in PLL.

**Application of PLL:** Frequency Multiplication, Frequency synthesizer and Skew reduction. Block Diagram of Digital PLL.



### Text Books

1. Behzad Razavi, "Design of Analog CMOS Integrated Circuits", McGraw-Hill, 2/e, 2002.
2. Phillip E. Allen, Douglas R. Holbery, CMOS Analog Circuit Design, Oxford, 2004.
3. Razavi B., Fundamentals of Microelectronics, Wiley student Edition 2014.
4. Baker, R.. (2010). CMOS: Circuit Design, Layout, and Simulation, Third Edition. 10.1002/9780470891179.

### COURSE CONTENTS AND LECTURE SCHEDULE

| No    | Topic                                                                                                                                           | No of Lecture/Tutorial Hours |
|-------|-------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|       | <b>Module 1</b>                                                                                                                                 | <b>7</b>                     |
| 1.1   | Review of MOS Characteristics.                                                                                                                  | 1                            |
| 1.2   | Second order effects (Subthreshold conduction, DIBL, Velocity Saturation etc..)                                                                 | 2                            |
| 1.3   | Introduction to Basic Current Mirror.                                                                                                           | 1                            |
| 1.4   | Cascode current Mirrors and Basic Concepts of Active Current Mirrors.                                                                           | 3                            |
|       | <b>Module 2</b>                                                                                                                                 | <b>7</b>                     |
| 2.1   | Single Stage Amplifiers-CS with resistive, Diode Connected and Current Source Load, CS with source Degeneration.                                | 2                            |
| 2.2   | Source Follower, common Gate Stage and Cascode Stage.                                                                                           | 2                            |
| 2.3   | Single-ended and differential operation, Basic differential pair.                                                                               | 1                            |
| 2.4   | Common-mode response, Differential pair with MOS load, Gilbert Cell.                                                                            | 2                            |
|       | <b>Module 3</b>                                                                                                                                 | <b>7</b>                     |
| 3.1   | Voltage Dividers- Resistor MOSFET divider, MOSFET only voltage divider.                                                                         | 1                            |
| 3.2   | Current Source Self Biasing- Threshold voltage referenced self-biasing, Diode referenced self-biasing, Thermal voltage referenced self-biasing. | 3                            |
| 3.3   | Bandgap Voltage References- Bandgap referenced biasing.                                                                                         | 1                            |
| 3.4   | Beta Multiplier Referenced Self Biasing- A Voltage Reference, Operation in the subthreshold region.                                             | 2                            |
| hline | <b>Module 4</b>                                                                                                                                 | <b>7</b>                     |
| 4.1   | Introduction to Switched Capacitor Circuits, Sample and hold circuit.                                                                           | 2                            |
| 4.2   | Switched Capacitor Resistor (different types).                                                                                                  | 2                            |
| 4.3   | Switched Capacitor Integrator (different types).                                                                                                | 2                            |
| 4.4   | Advantages of Switched Capacitor Circuits, Limitations, Applications.                                                                           | 1                            |

|     |                                                                                         |                 |
|-----|-----------------------------------------------------------------------------------------|-----------------|
|     | <b>Module 5</b>                                                                         | <b>7</b>        |
| 5.1 | Mathematical model of VCO, Phase Detector, Basic PLL Topology.                          | 1               |
| 5.2 | Type I and Type II (Charge Pump) PLL, Stability Analysis of PLL.                        | 2               |
| 5.3 | Non Ideal Effects in PLL.                                                               | 1               |
| 5.4 | Application of PLL- Frequency Multiplication, Frequency synthesizer and Skew reduction. | 2               |
| 5.5 | Block Diagram of Digital PLL.                                                           | 1               |
|     | <b>Total Hours</b>                                                                      | <b>35 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Summarize the working of an NMOS transistor.
2. Explain the concept of an active current mirror.
3. Describe the operation of a simple current mirror.

#### Course Outcome 2 (CO 2):

1. Develop small signal model for various amplifier configurations.
2. Analyze the effect of cascading of stages.
3. Calculate the small signal gain of differential pair if the bias voltages are equal.

#### Course Outcome 3 (CO 3):

1. Describe the operation of a resistor-MOSFET voltage divider.
2. Define bandgap voltage reference.
3. Mention the importance of subthreshold operation in MOSFETs.

#### Course Outcome 4 (CO 4):

1. State the basic principle of switched capacitor operation.
2. Describe the function of a sample-and-hold circuit.
3. State the purpose of a switched capacitor integrator.

**Course Outcome 5 (CO 5):**

1. List the basic components of a PLL.
2. Define phase detector and its role in PLL.
3. Describe the implementation of PLL for Frequency Multiplication, Frequency synthesizer and Skew reduction.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2028**

***Course Code: B24EC4P44***

***Course Name: ANALOG CMOS DESIGN***

**Max. Marks: 100**

**Duration: 3 hours**

***PART A***

***Answer all questions. Each question carries 3 marks***

1. Explain Body effect. How body Effect affect the Threshold voltage?
2. Describe the concept of active current mirror.
3. Calculate the Common mode Gain of a differential Pair.
4. Explain the working of Gilbert Cell as Analog voltage Multiplier.
5. Explain the concept of a MOSFET voltage divider.
6. Describe diode-referenced self-biasing.
7. List any two advantages of switched capacitor circuits.
8. Define charge transfer in switched capacitor circuits.
9. Explain the working of Phase Detectors?
10. Explain the Block diagram of Digital PLL?

***PART B***

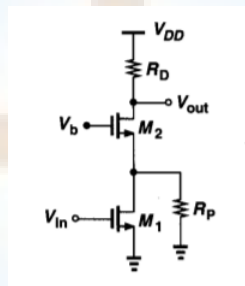
***Answer any one question from each module. Each question carries 14 marks***

### Module I

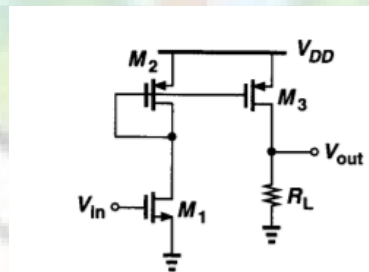
11. a) Explain any three second-order effects in MOSFETs and their impact on device performance. (7)  
b) Explain the working of a simple current mirror with neat diagram. (7)
12. With suitable diagrams, explain simple and cascode current mirrors and discuss their advantages and disadvantages. (14)

### Module II

13. a) Derive the expression of a common source stage with diode connected load. (7)  
b) Calculate the voltage gain of the circuit. (7)



14. Calculate the small signal voltage gain of the circuit shown below. (14)



### Module III

15. a) Explain thermal voltage referenced self-biasing and its importance. (7)  
b) Explain the operation of a beta multiplier reference circuit. (7)
16. Explain MOSFET voltage dividers and self-biasing techniques with suitable diagrams and discuss their importance in analog circuits. (14)

### Module IV

17. Explain switched capacitor resistors and integrators in detail, including different types. (14)
18. Explain the principle of switched capacitor circuits and describe their operation with suitable diagrams. (14)

***Module V***

- 19. a) Explain Type 1 and charge pump PLL. (5)  
b) Explain various non ideal effects in PLL. (9)
- 20. a) Describe various applications of PLL. (10)  
b) Describe the causes of stability degradation in charge pump PLL. (4)





| B24EC4P45 | OPTO-ELECTRONIC DEVICES | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|-------------------------|---|---|---|---|--------|----------------------|
|           |                         | 2 | 1 | 0 | 4 | 3      | 2024                 |

**Preamble**

This course aims to develop an insight into the working principles and performance parameters of various optoelectronic devices used for optical networks and communication.

**Prerequisites**

B24EC2T04 : SOLID STATE DEVICES

**Course Outcomes**

After completion of the course, the student will be able to:

|      |                                                                                                                           |
|------|---------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Explain the physics of optical processes in semiconductors. [Understand]                                                  |
| CO 2 | Analyse different types of optical sources and photodetectors employed in optoelectronic systems. [Analyse]               |
| CO 3 | Design simple systems using optoelectronic devices while considering performance and implementation constraints. [Create] |
| CO 4 | Explain various optical modulators and optoelectronic devices. [Understand]                                               |
| CO 5 | Explain various optical devices used for optical communication. [Understand]                                              |

**Mapping of Course Outcomes With Program Outcomes**

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    |      |      |      |      |      |      |      |       |       |
| CO 2 | 2    | 3    | 1    | 2    |      |      |      |      |      |       |       |
| CO 3 | 3    | 3    | 3    | 1    | 1    |      | 1    |      |      |       | 2     |
| CO 4 | 2    | 2    | 1    |      | 1    |      |      |      |      |       |       |
| CO 5 | 2    | 2    | 2    |      | 1    |      | 1    |      |      |       |       |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 50                    | 50              | 50                                 |
| Apply            | 10                    | 10              | 10                                 |
| Analyse          | 20                    | 20              | 20                                 |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have a maximum of 2 subdivisions.

## SYLLABUS

### MODULE 1

**Fundamentals of Semiconductor Optoelectronics:** Optical processes in semiconductors: electron-hole generation and recombination, Absorption, Auger recombination, Heat generation and dissipation, Heat sources. Various light production mechanisms, Indirect band gap materials, Semiconductors used for optical applications, Basic principle of LED and LASER, Spontaneous emission and Stimulated Emission, Coherence of sources.

### MODULE 2

**Optical Sources:** Construction and operation of LEDs, Heterojunctions, Surface Emitter and Edge Emitter LEDs, Characteristics of LEDs, LASERs, Threshold condition for lasing, Line Broadening Mechanisms, Fabry-Perot Lasers, Distributed Feedback(DFB) Lasers, Distributed Bragg Reflector(DBR) Lasers, Vertical Cavity Surface Emitting Lasers (VCSELs), In-Fibre Lasers.

### MODULE 3

**Optical Detectors:** Principle of Photo Detection, Working of LDR, PN diode, PIN diode, Avalanche Photodiode (APD), Characteristics of APD, Resonant Cavity Photo detector, Photo Transistor, Quantum efficiency, Responsivity, Noise in Photo detectors, Thermal Noise, Dark Current, Shot Noise, Quantum limit of Optical Detection.

Design and implement micro-projects using various optoelectronic devices.

### MODULE 4

**Optoelectronic Devices and Modulators:** Optoelectronic ICs, Advantages, Liquid Crystal Display: Structure, TFT display: Structure, Polymer LED, Organic LED, Optical Modulators using PN junction, Electro-Optic Modulators, Acousto-Optic Modulators, Raman-Nath Modulators, Optical switching and Logic devices, Optical Memory. Solar Cells: basic working principle, VI Characteristics, Different types of solar cells.

### MODULE 5

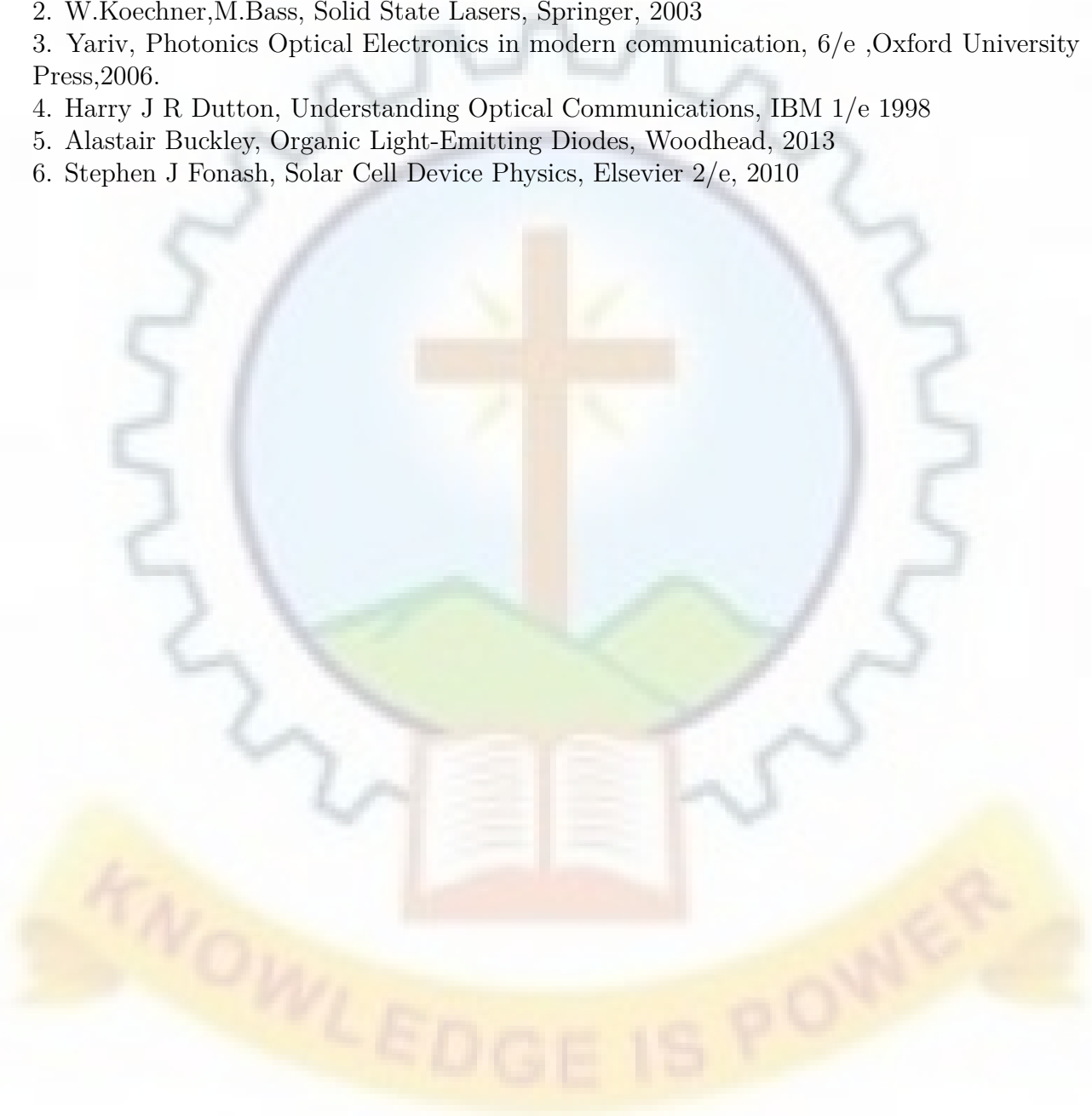
**Optical Devices in Optoelectronic Networks:** Introduction to optical components, Splitters and Couplers, Directional Couplers, Fiber Bragg Gratings, Multiplexers, Attenuators, Isolators, Circulators, Fixed Filters, Tunable Filters, Add Drop Multiplexers, Waveguide Grating Routers, Optical Cross Connects, Wavelength Converters, Optical Bistable Devices.

**Text Book**

1. Pallab Bhattacharya: Semiconductor Optoelectronic Devices, Pearson, 2009

**Reference Books**

1. Mark Csele, Fundamentals of Light Sources and Lasers, Wiley-Interscience, 2004
2. W.Koechner,M.Bass, Solid State Lasers, Springer, 2003
3. Yariv, Photonics Optical Electronics in modern communication, 6/e ,Oxford University Press,2006.
4. Harry J R Dutton, Understanding Optical Communications, IBM 1/e 1998
5. Alastair Buckley, Organic Light-Emitting Diodes, Woodhead, 2013
6. Stephen J Fonash, Solar Cell Device Physics, Elsevier 2/e, 2010



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                        | No of Lecture/Tutorial Hours |
|-----|--------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                              | <b>8</b>                     |
| 1.1 | Optical processes in semiconductors: electron-hole generation and recombination, Absorption.                 | 2                            |
| 1.2 | Auger recombination, Heat generation and dissipation, Heat sources.                                          | 2                            |
| 1.3 | Various light production mechanisms                                                                          | 1                            |
| 1.4 | Indirect band gap materials, Semiconductors used for optical applications.                                   | 1                            |
| 1.5 | Basic principle of LED and LASER, Spontaneous emission and Stimulated Emission, Coherence of sources.        | 2                            |
|     | <b>Module 2</b>                                                                                              | <b>6</b>                     |
| 2.1 | Construction and operation of LEDs, Heterojunctions.                                                         | 1                            |
| 2.2 | Surface Emitter and Edge Emitter LEDs, Characteristics of LEDs.                                              | 1                            |
| 2.3 | LASERs, Threshold condition for lasing, Line Broadening Mechanisms.                                          | 1                            |
| 2.4 | Fabry-Perot Lasers, Distributed Feedback(DFB) Lasers.                                                        | 1                            |
| 2.5 | Distributed Bragg Reflector (DBR) Lasers, Vertical Cavity Surface Emitting Lasers (VCSELs), In-Fibre Lasers. | 2                            |
|     | <b>Module 3</b>                                                                                              | <b>6</b>                     |
| 3.1 | Principle of Photo Detection, Working of LDR, PN diode, PIN diode.                                           | 1                            |
| 3.2 | Avalanche Photodiode (APD), Characteristics of APD.                                                          | 1                            |
| 3.3 | Resonant Cavity Photo detector, Photo Transistor.                                                            | 1                            |
| 3.4 | Quantum efficiency, Responsivity.                                                                            | 1                            |
| 3.5 | Noise in Photo detectors, Thermal Noise, Dark Current, Shot Noise, Quantum limit of Optical Detection.       | 2                            |
| 3.6 | Design and implement micro-projects using various optoelectronic devices.                                    | 0                            |
|     | <b>Module 4</b>                                                                                              | <b>9</b>                     |
| 4.1 | Optoelectronic ICs, Advantages.                                                                              | 1                            |
| 4.2 | Liquid Crystal Display: Structure. TFT display: Structure.                                                   | 1                            |
| 4.3 | Polymer LED, Organic LED, Optical Modulators using PN junction.                                              | 1                            |
| 4.4 | Electro-Optic Modulators, Acousto-Optic Modulators, Raman-Nath Modulators.                                   | 2                            |
| 4.5 | Optical switching and Logic devices, Optical Memory.                                                         | 2                            |
| 4.6 | Solar Cells: basic working principle, VI Characteristics, Different types of solar cells.                    | 2                            |

|     |                                                                                                                                |                 |
|-----|--------------------------------------------------------------------------------------------------------------------------------|-----------------|
|     | <b>Module 5</b>                                                                                                                | <b>7</b>        |
| 5.1 | Introduction to optical components, Splitters and Couplers.                                                                    | 1               |
| 5.2 | Directional Couplers, Fiber Bragg Gratings, Multiplexers, Attenuators, Isolators, Circulators, Fixed Filters, Tunable Filters. | 3               |
| 5.3 | Add Drop Multiplexers, Waveguide Grating Routers, Optical Cross Connects.                                                      | 2               |
| 5.4 | Wavelength Converters, Optical Bistable Devices.                                                                               | 1               |
|     | <b>Total Hours</b>                                                                                                             | <b>36 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Differentiate between spontaneous emission and stimulated emission.
2. If the band gap of GaAs is 1.44eV at 300K, determine the wavelength of light emitted by GaAs LED.

#### Course Outcome 2 (CO 2):

1. Explain any one line broadening mechanism in LASER Sources.
2. Explain the concept of dark current.

#### Course Outcome 3 (CO 3):

1. Design a security system that uses the photo detection principle to detect intruders.
2. A significant amount of energy is wasted on street lighting because the lights are not switched on and off at the proper times. Design a simple circuit using optoelectronic devices to overcome this problem.

#### Course Outcome 4 (CO 4):

1. Explain the operating principle of organic LEDs.
2. Explain the concept of electro-optic effect.



**Course Outcome 5 (CO 5):**

1. Explain the operating principle of waveguide grating routers.
2. Determine the physical grating period required for FBG for rejecting 980 nm optical signals. Assume that the average refractive index of the core = 1.45.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 3**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DEC 2027**

**Course Code: B24EC4P45**

**Course Name: OPTO-ELECTRONIC DEVICES**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Differentiate between spontaneous emission and stimulated emission.
2. Determine the wavelength of light emitted by GaAs LED. Assume that the band gap of GaAs is 1.44eV at 300K.
3. Explain the concept of a surface emitter LED.
4. Explain any one line broadening mechanism in LASER Sources.
5. Determine the photo current generated for an incident optical signal strength 600 nW on a PIN photodiode with responsivity 7.5 A/W.
6. Discuss the concept of dark current.
7. Explain the concept of electro-optic effect.
8. Discuss the principle of optical memory.
9. List the different types of Wavelength division multiplexers and demultiplexers used of optical field access.
10. Explain the working principle of circulators.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) With the help of diagrams, explain the concept of radiative and non-radiative recombination. (7)  
b) Explain what is meant by coherence of optical sources. (7)
12. a) Discuss the various light production mechanisms in materials. (7)  
b) With the help of a diagram, explain the operating principle of LEDs. (7)

**Module II**

13. a) With the help of a suitable diagram, explain the working principle of a DFB Laser. (9)  
b) List the various features and characteristics of LEDs. (5)
14. a) With a neat diagram, explain the principle of Surface Emitting LEDs and compare its features with edge emitting LEDs. (8)  
b) A Light Emitting Diode gives 500 mW output power when minority carrier lifetime is 4 ns. Determine the output optical power when LED is modulated with 50 MHz frequency with rms current equal to same dc current. (6)

**Module III**

15. a) Explain various noise mechanisms in optical detectors. (5)  
b) Discuss the construction and operating principle of PIN photodiode. (9)
16. a) Explain different techniques commonly used for measuring high speed response of photodetectors. (7)  
b) Calculate the photocurrent density of a Si p-i-n photodiode with 8  $\mu\text{m}$  i-region when 0.87  $\mu\text{m}$  light power density  $0.5\text{W}/\text{cm}^2$  is incident upon it. It is assumed that the top illuminated surface is coated with anti-reflection coating. Given that the absorption coefficient at 0.87  $\mu\text{m}$  is 600. (7)

**Module IV**

17. a) Explain acousto-optic effect and Raman-Nath modulator. (9)  
b) Explain the working principle of organic LEDs. (5)
18. a) Discuss the concept of solar cells. (5)  
b) With the help of a diagram, explain the concept of Polymer LEDs. List the advantages and disadvantages of Polymer LEDs. (9)

**Module V**

19. a) Discuss the principle of tunable filters. (8)  
b) Explain the principle and working of waveguide grating routers. (6)
20. a) Explain different types of fixed optical filters. (9)  
b) Determine the physical grating period required for FBG for rejecting 980 nm optical signals. Take average refractive index of the core = 1.45. (5)

| B24EC4G21 | INTERNET OF THINGS | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|--------------------|---|---|---|---|--------|----------------------|
|           |                    | 2 | 1 | 0 | 4 |        |                      |

**Preamble**

This course introduces the fundamentals of the Internet of Things (IoT), covering architecture, hardware platforms, sensors, communication protocols, and cloud integration, while providing both theoretical understanding and practical exposure to real-world IoT applications

**Prerequisites**

Nil

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                                               |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Explain the fundamental concepts, architecture, physical and logical design, enabling technologies, and deployment models of Internet of Things (IoT) systems.[Understand,Apply]              |
| <b>CO 2</b> | Identify and analyze IoT devices, building blocks, and connectivity technologies, including wired and wireless communication protocols and Internet protocols used in IoT.[Understand, Apply] |
| <b>CO 3</b> | Demonstrate understanding of IoT device-to-cloud integration, cloud service models, IoT gateways, and basic data visualization using popular IoT cloud platforms.[Understand, Apply]          |
| <b>CO 4</b> | Apply knowledge of IoT hardware and software platforms and understand IoT system management and advanced networking concepts.[Understand, Apply]                                              |
| <b>CO 5</b> | Analyze IoT security, privacy issues, and vulnerabilities, and smart city IoT architectures, security challenges, practical implementations, and emerging trends.. [Understand, Analyse]      |

**Mapping of Course Outcomes With Program Outcomes**

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|
| CO1 | 3    | 2    | 2    |      | 2    | 1    | 1    |      | 2    | 2     | 2     |
| CO2 | 2    | 3    | 2    | 2    | 3    | 1    |      | 2    | 2    | 1     | 2     |
| CO3 | 2    | 3    | 2    | 2    | 2    | 1    | 1    | 1    | 1    | 2     | 2     |
| CO4 | 3    | 2    | 3    | 1    | 2    |      |      |      | 2    | 2     | 1     |
| CO5 | 2    | 2    | 3    | 2    | 2    | 1    |      |      | 2    | 2     | 1     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Fundamentals of IoT:** Introduction to IoT- Definition and Characteristics- Physical and Logical Design of IoT- IoT Architectural View- IoT Enabling Technologies- IoT Levels & Deployment Templates. Components of an IoT System- Sensors, actuators, smart objects, sensor networks and communicating with smart objects  
Things in IoT - Familiarization with Arduino for IoT- Popular Arduino IoT Platforms and Tools:- Arduino IoT Cloud, ThingSpeak, MQTT.

### MODULE 2

**IoT Devices and connectivity:** IoT Devices- Building blocks of IoT device-IoT Connectivity Technologies–Wired-UART,I2C, SPI,LAN-Wireless communication-Zigbee, Wireless HART, RFID, NFC, LoRa, WiFi, Bluetooth -Internet Protocols for IoT- IPv6,6LoWPAN- Overview of the 6LoWPAN Adaptation Layer -Application Layer Protocols- MQTT, CoAP, HTTP/REST- Comparison of protocols

### MODULE 3

**IoT Cloud Integration & Data Analytics:** IoT Device to Cloud Connectivity-AWS IoT Core, Azure IoT Hub, Google Cloud IoT Core-Cloud service models (IaaS/PaaS/SaaS), IoT-specific services, scalability, Cloud Deployment Models-public, private, hybrid/multi-cloud-Data Visualization- IoT data flow architecture (device → gateway → cloud → dashboard)-IoT Cloud Platforms-AWS IoT,Azure IoT, Thingspeak-Internet of Things (IoT) Gateways.

### MODULE 4

**IoT Hardware, Software, and System Management:** IoT Hardware- Raspberry-Pi-Board-Linux on Raspberry-Pi-Raspberry-Pi Interfaces (serial, SPI, I2C). Raspberry Pi interfacing and programming examples using python (LED, switch, sensor)- Software Stack – overview of Operating systems, Firmware, Middle ware, Application software used in IoT–.- Advanced Networking for IoT: SDN and NFV-IoT Systems Management-IoT Systems Management with NETCONF-YANG

### MODULE 5

**IoT Security, Privacy, and Smart City Applications:** IoT privacy, security and vulnerabilities solutions, vulnerabilities, security requirements, threat analysis, security tomography, layered attacker model, Identity management, access control, secure message com-



munication. Smart City IoT Architecture-Street Layer, City Layer, Data Center Layer, Services Layer- Smart City Security Architecture - Smart City Use- Case Implementations - Practical Scenarios- Implementation Challenges and Future Trends

**Text Books**

1. Arshdeep Bahga & Vijay Madisetti, Internet of Things: A Hands-On Approach, Universities Press, 2014
2. Adrian McEwen & Hakim Cassimally, Designing the Internet of Things, Wiley, 2013
3. Sudip Misra, Anandarup Mukherjee & Arijit Roy. Introduction to IoT. Cambridge University Press. 2021
4. Olivier Hersent, David Boswarthick, & Omar Elloumi, The Internet of Things: Key Applications and Protocols, Wiley, 2012.
5. Hanes, T., Salgueiro, G., Grossetete, P., Barton, R., & Henry, J., IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, Cisco Press, 2017.
6. Daniel Minoli, Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications, Wiley, 2013.
7. Rajkumar Buyya & Amir Vahid Dastjerdi, Internet of Things: Principles and Paradigms, Elsevier, 2016.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                                                  | No of Lecture/Tutorial Hours |
|-----|----------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                        | <b>8</b>                     |
| 1.1 | Introduction to IoT: Definition, characteristics, and evolution                        | 1                            |
| 1.2 | Physical and logical design of IoT                                                     | 2                            |
| 1.3 | IoT architectural view and enabling technologies                                       | 1                            |
| 1.4 | IoT levels and deployment templates                                                    | 1                            |
| 1.5 | Components of an IoT system                                                            | 1                            |
| 1.6 | Things in IoT: Arduino Familiarization                                                 | 1                            |
| 1.7 | Arduino IoT platforms and tools – Arduino IoT Cloud, ThingSpeak, MQTT                  | 1                            |
|     | <b>Module 2</b>                                                                        | <b>8</b>                     |
| 2.1 | IoT devices-building blocks of an IoT device                                           | 1                            |
| 2.2 | Wired connectivity technologies: UART, I2C, SPI, LAN                                   | 1                            |
| 2.3 | Wireless connectivity technologies: Zigbee, WirelessHART, RFID, NFC                    | 1                            |
| 2.4 | Long-range and short-range wireless technologies: LoRa, Wi-Fi, Bluetooth               | 1                            |
| 2.5 | Internet protocols for IoT: IPv6 and 6LoWPAN; overview of the 6LoWPAN adaptation layer | 2                            |
| 2.6 | Application layer protocols: MQTT, CoAP, HTTP/REST; comparison of IoT protocols        | 2                            |
|     | <b>Module 3</b>                                                                        | <b>6</b>                     |
| 3.1 | IoT device-to-cloud connectivity concepts                                              | 1                            |
| 3.2 | IoT cloud platforms                                                                    | 1                            |
| 3.3 | Cloud service models                                                                   | 1                            |
| 3.4 | Cloud deployment models                                                                | 1                            |
| 3.5 | IoT data flow architecture                                                             | 1                            |
|     | <b>Module 4</b>                                                                        | <b>8</b>                     |
| 4.1 | IoT hardware platforms: Raspberry Pi board architecture                                | 1                            |
| 4.2 | Raspberry Pi interfaces (serial, SPI, I2C)                                             | 2                            |
| 4.3 | Raspberry Pi interfacing and Python programming examples (LED, switch, sensors)        | 2                            |
| 4.4 | IoT software stack: operating systems, firmware, middleware, application software      | 1                            |
| 4.5 | Advanced networking for IoT: SDN and NFV                                               | 1                            |
| 4.6 | IoT system management: NETCONF and YANG overview                                       | 1                            |
|     | <b>Module 5</b>                                                                        | <b>5</b>                     |
| 5.1 | IoT privacy issues, vulnerabilities, and security requirements                         | 1                            |

|     |                                                                             |                 |
|-----|-----------------------------------------------------------------------------|-----------------|
| 5.2 | Threat analysis, security taxonomy, and layered attacker model              | 1               |
| 5.3 | Identity management, access control, and secure message communication       | 1               |
| 5.4 | Smart City IoT architecture: street, city, data center, and services layers | 1               |
| 5.5 | Practical scenarios, implementation challenges, and future trends in IoT    | 1               |
|     | <b>Total Hours</b>                                                          | <b>35 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the definition and characteristics of the Internet of Things (IoT). Describe the physical and logical design of IoT with suitable examples.
2. Discuss the IoT architectural view and enabling technologies. Explain IoT levels and deployment templates with neat diagrams.

#### Course Outcome 2 (CO 2):

1. Explain the building blocks of an IoT device. Describe wired and wireless connectivity technologies used in IoT systems.
2. Discuss Internet protocols for IoT, including IPv6 and 6LoWPAN. Explain the application layer protocols MQTT, CoAP, and HTTP/REST with a comparison.

#### Course Outcome 3 (CO 3):

1. Explain IoT device-to-cloud connectivity. Describe the features of AWS IoT Core, Azure IoT Hub, and Google Cloud IoT Core.
2. Discuss cloud service models (IaaS, PaaS, SaaS) and cloud deployment models. Explain the role of IoT gateways and data visualization in IoT systems.

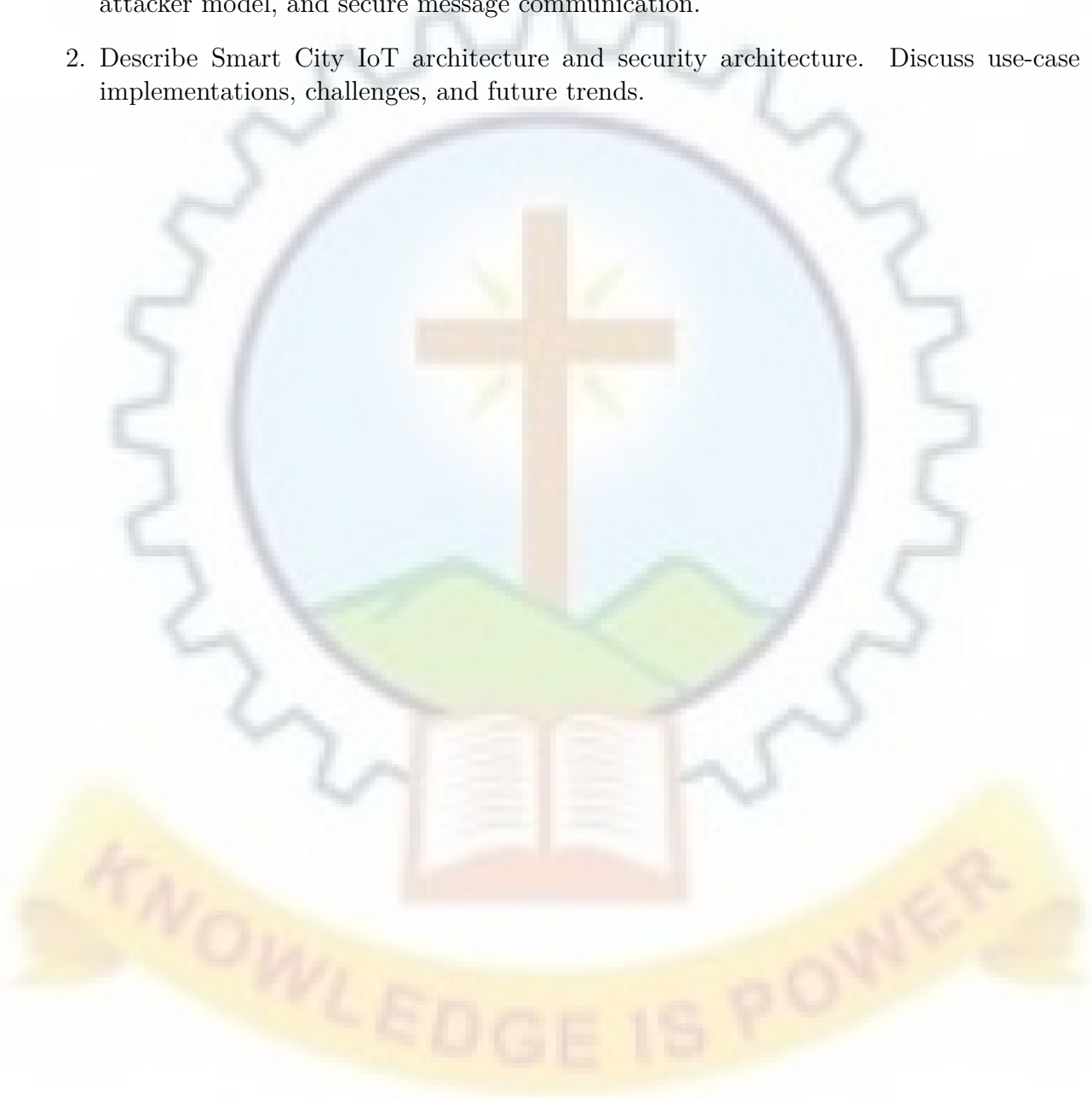
#### Course Outcome 4 (CO 4):

1. Explain the architecture of Raspberry Pi. Describe Linux on Raspberry Pi and interfacing using serial, SPI, and I2C with examples.

2. Discuss the IoT software stack. Explain the need for IoT system management and briefly describe NETCONF and YANG.

**Course Outcome 5 (CO 5):**

1. Explain IoT security requirements and vulnerabilities. Discuss threat analysis, layered attacker model, and secure message communication.
2. Describe Smart City IoT architecture and security architecture. Discuss use-case implementations, challenges, and future trends.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2028**

**Course Code: B24EC4G21**

**Course Name: INTERNET OF THINGS**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define Internet of Things (IoT) and list its key characteristics.
2. Differentiate between physical design and logical design of IoT.
3. List the main building blocks of an IoT device.
4. Compare any two wireless connectivity technologies used in IoT.
5. What is IoT device-to-cloud connectivity? Give examples of IoT cloud platforms.
6. Explain cloud service models used in IoT.
7. List the major hardware and software components used in an IoT system.
8. What is middleware? Explain its role in the IoT software stack.
9. List the major security requirements in IoT systems.
10. List the layers of Smart City IoT architecture..

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain the definition and characteristics of the Internet of Things (IoT). Describe the physical and logical design of IoT with suitable examples. (7)  
b) Discuss the IoT architectural view and enabling technologies. Explain IoT levels and deployment templates. (7)
12. a) Illustrate the main design principles of an IoT architecture. (7)  
b) Discuss the challenges and characteristics of IoT systems in modern industrial applications. (7)

**Module II**

13. a) Explain the building blocks of an IoT device with a block diagram. (7)  
b) Discuss wired and wireless connectivity technologies used in IoT systems. (7)
14. a) Explain IPv6 and 6LoWPAN protocol stack for IoT applications. (7)  
b) Compare MQTT, CoAP, and HTTP/REST protocols used in IoT. (7)

**Module III**

15. a) Explain IoT device-to-cloud connectivity with suitable architecture. (7)  
b) Discuss the features of AWS IoT Core, Azure IoT Hub, and Google Cloud IoT Core. (7)
16. a) Explain cloud service models and deployment models used in IoT. (7)  
b) Describe the role of IoT gateways and data visualization in IoT systems. (7)

**Module IV**

17. Explain the Raspberry Pi hardware architecture and discuss Linux support on Raspberry Pi for IoT applications. Describe serial, SPI, and I2C interfaces with suitable examples. (14)
18. Describe the IoT software stack in detail, including operating systems, firmware, middleware, and application software. Explain IoT systems management and discuss the role of NETCONF and YANG. (14)

**Module V**

19. Discuss IoT privacy and security requirements in detail. Explain common vulnerabilities, threat analysis methods, and the layered attacker model used in securing IoT systems. (14)
20. Explain Smart City IoT architecture with reference to street layer, city layer, data center layer, and services layer. Discuss Smart City security architecture, implementation challenges, and future trends with suitable use cases. (14)



| B24EC4G22 | BIOMEDICAL<br>ENGINEERING | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|---------------------------|---|---|---|---|--------|-------------------------|
|           |                           | 2 | 1 | 0 | 4 | 3      | 2024                    |

**Preamble**

This course applies engineering principles to understand biological systems and develop medical instruments for diagnosis and treatment. This course introduces fundamental concepts of bioelectric signals, biomedical instrumentation, and medical imaging techniques used in modern healthcare. automation.

**Prerequisites**

NIL

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                       |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Describe the basic concepts of biomedical engineering, human physiological systems, and sources of bioelectric potentials.[Understand, Remember]      |
| <b>CO 2</b> | Explain the principles and measurement techniques of cardiovascular systems such as ECG and blood pressure monitoring methods..[Understand, Remember] |
| <b>CO 3</b> | Explain the electrical activity of the nervous and muscular systems and the basic concepts of EEG and EMG signal acquisition.[Understand,Remember]    |
| <b>CO 4</b> | Describe the operation and applications of biomedical instrumentation and therapeutic equipment used in healthcare systems.[Understand,Apply]         |
| <b>CO 5</b> | Explain the basic principles and applications of medical imaging techniques such as X-ray, CT, ultrasound, and MRI.[Understand, Remember]             |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 1    |      |      |      | 1    |      | 1    |      |       | 2     |
| <b>CO 2</b> | 3    | 2    |      | 1    | 1    | 1    | 1    |      |      |       | 2     |
| <b>CO 3</b> | 3    | 3    | 1    | 1    | 1    |      |      |      | 1    | 1     | 2     |
| <b>CO 4</b> | 3    | 2    | 1    |      | 2    |      | 1    |      |      |       | 2     |
| <b>CO 5</b> | 3    | 1    |      |      | 2    |      | 1    | 1    | 1    | 2     | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 70                    | 70                 | 70                                    |
| Apply            | 10                    | 10                 | 10                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Introduction to Biomedical Systems :** Introduction to bio-medical engineering, Man-Instrument System, overview of anatomy and physiological systems of the body. Sources of bio-electric potential: Resting and action potential, propagation of action potentials. Bio-electric potentials examples (ECG, EEG, EMG, ERG, EOG, EGG concept only.) Electrode theory: Nernst relation, Electrode skin interface, Bio potential electrodes: Microelectrodes, skin surface electrodes, needle electrodes.

### MODULE 2

**Cardiovascular Measurements:** Heart and cardiovascular system (brief discussion), electro conduction system of the heart. Electrocardiography, ECG machine block diagram, ECG lead configurations, ECG recording system, Einthoven triangle, analysis of ECG signals. Measurement of blood pressure: Direct, indirect, and relative methods of blood pressure measurement, auscultatory method, oscillometric and ultrasonic non-invasive pressure measurements.

### MODULE 3

**Nervous and Respiratory Systems :** Human nervous system. Neuron, action potential of brain, brain waves, types of electrodes, placement of electrodes, evoked potential, EEG recording, analysis of EEG. Electrical activity of muscles- EMG. Signal Acquisition and analysis. Applications of EMG - myoelectric control system. Physiology of respiratory system (overview), Respiratory parameters, spirometer, body plethysmographs, gas exchange and distribution.

### MODULE 4

**Biomedical Instrumentation and Therapeutic Equipment :** Instrumentation for clinical laboratory: Bio electric amplifiers-instrumentation amplifiers isolation amplifiers-chopper stabilized amplifiers - : Oximeters, pH meter, blood cell counter. Therapeutic Equipment: Principle, block schematic diagram, working and applications of pacemakers, cardiac defibrillators, dialyzers, ventilators. Biomedical Telemetry system: Components of biotelemetry system, application of telemetry in medicine.

### MODULE 5

**Medical Imaging Systems (Basic Principles):** X-ray imaging - Properties and production of X-rays, X-ray machine, applications of X-rays in medicine. Computed Tomography: Principle, image reconstruction, scanning system and applications. Ultrasonic imaging systems: Basic pulse echo system, propagation of ultrasonic through tissues and reflections, display types, A-Scan, B-Scan, M-Scan, applications, real-time ultrasonic imaging systems and probes. Magnetic Resonance Imaging – Basic NMR components, biological effects, and advantages of NMR imaging.

### Text Books

1. Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, Biomedical Instrumentation and Measurements, PHI, 2nd Edition, 2004 .
- 2.R. S. Khandpur, Handbook of Biomedical Instrumentation, Tata Mc Graw Hill.
- 3.John G Webster, “Medical Instrumentation application and design”, John Wiley 3rde/d.
4. J. J. Carr, “Introduction to Biomedical Equipment Technology”, Pearson Education 4th e/d.
5. Richard Aston, “Principle of Biomedical Instrumentation and Measurement”. Merrill Education/Prentice Hall.
6. Barbara Christe, Introduction to Biomedical Instrumentation, Cambridge University Press, 2008.

### COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                     | No of Lecture/Tutorial Hours |
|-----|---------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                           | <b>8</b>                     |
| 1.1 | Introduction to Biomedical Engineering, Man-Instrument System .                                                           | 1                            |
| 1.2 | Overview of anatomy and physiological systems of the body.                                                                | 2                            |
| 1.3 | ources of bio-electric potentials: Resting potential, Action potential, Propagation of action potentials.                 | 2                            |
| 1.4 | Bioelectric potentials (concept only):ECG, EEG, EMG, ERG, EOG, EGG.                                                       | 1                            |
| 1.5 | Electrode theory, Nernst relation,Electrode-skin interface.                                                               | 1                            |
| 1.6 | Bio-potential electrodes: Microelectrodes, Skin surface electrodes, Needle electrodes.                                    | 1                            |
|     | <b>Module 2</b>                                                                                                           | <b>7</b>                     |
| 2.1 | Heart and cardiovascular system (brief discussion).                                                                       | 1                            |
| 2.2 | Electrical conduction system of the heart, Electrocardiography (ECG), ECG machine block diagram, Analysis of ECG signals. | 2                            |
| 2.3 | ECG lead configurations,ECG recording system,Einthoven triangle.                                                          | 1                            |
| 2.4 | Measurement of blood pressure: Direct, indirect and relative methods of blood pressure measurement.                       | 2                            |
| 2.5 | Auscultatory method, oscillometric and ultrasonic noninvasive pressure measurements.                                      | 1                            |
|     | <b>Module 3</b>                                                                                                           | <b>7</b>                     |
| 3.1 | Human nervous system, Neuron and action potential of brain.                                                               | 1                            |

|     |                                                                                                                                                                                                                |                 |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 3.2 | Brain waves, EEG recording system, Analysis of EEG.                                                                                                                                                            | 1               |
| 3.3 | Types and placement of electrodes, Evoked potentials.                                                                                                                                                          | 1               |
| 3.4 | Electromyography (EMG) :Electrical activity of muscles, Signal acquisition and analysis, Applications of EMG, Myoelectric control systems.                                                                     | 2               |
| 3.5 | Respiratory System: Physiology of respiratory system (overview), Respiratory parameters.                                                                                                                       | 1               |
| 3.6 | Spirometer, Body plethysmograph, Gas exchange and distribution.                                                                                                                                                | 1               |
|     | <b>Module 4</b>                                                                                                                                                                                                | <b>7</b>        |
| 4.1 | Clinical Laboratory Instrumentation: Bioelectric amplifiers, Instrumentation amplifiers.                                                                                                                       | 1               |
| 4.2 | Isolation amplifiers, Chopper stabilized amplifiers.                                                                                                                                                           | 1               |
| 4.3 | Medical Instruments: Oximeters, pH meter, Blood cell counter.                                                                                                                                                  | 2               |
| 4.4 | Therapeutic Equipments : Principle, block diagram, working and applications of: Pacemakers, Cardiac defibrillators.                                                                                            | 1               |
| 4.5 | Principle, block diagram, working and applications of : Dialyzers, Ventilators.                                                                                                                                | 1               |
| 4.6 | Biomedical Telemetry: Components of biotelemetry system, Applications of telemetry in medicine.                                                                                                                | 1               |
|     | <b>Module 5</b>                                                                                                                                                                                                | <b>7</b>        |
| 5.1 | X-ray Imaging: Properties and production of X-rays, X-ray machine Applications in medicine.                                                                                                                    | 1               |
| 5.2 | Computed Tomography (CT): Principle, Image reconstruction, Scanning system, Applications                                                                                                                       | 2               |
| 5.3 | Ultrasonic Imaging : Basic pulse-echo system, Propagation of ultrasound through tissues, Reflections and display types- A-Scan , B-Scan, M-Scan. Real-time ultrasonic imaging systems, Probes and applications | 2               |
| 5.4 | Magnetic Resonance Imaging (MRI)-Basic NMR components, Biological effects, Advantages of MRI                                                                                                                   | 2               |
|     | <b>Total Hours</b>                                                                                                                                                                                             | <b>36 Hours</b> |



## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1):**

1. Explain the Man-Instrument system with a neat block diagram.
2. Describe the origin of bioelectric potentials and explain resting and action potential.
3. Explain the Nernst relation and its significance in bioelectrodes.

### **Course Outcome 2 (CO 2):**

1. Explain the ECG recording system with a block diagram.
2. Describe Einthoven's triangle and ECG lead configurations.
3. Explain different methods of blood pressure measurement with suitable diagrams.

### **Course Outcome 3 (CO 3):**

1. Explain the generation and characteristics of brain waves and EEG recording system.
2. Describe the principle of EMG and its applications in myoelectric control systems.
3. Explain the measurement of respiratory parameters using spirometer and body plethysmograph.

### **Course Outcome 4 (CO 4):**

1. Explain the working of instrumentation amplifiers used in biomedical signal acquisition.
2. Describe the principle and working of a cardiac pacemaker or defibrillator.
3. Explain the components and applications of biomedical telemetry systems.

### **Course Outcome 5 (CO 5):**

1. Explain the production and properties of X-rays and their applications in medical imaging.
2. Describe the principle of Computed Tomography (CT) scanning.
3. Explain the basic principle of ultrasonic imaging and different scan modes (A, B, M).



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24EC4G22**

**Course Name: BIOMEDICAL ENGINEERING**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define biomedical engineering.
2. What are bioelectric potentials? Give examples.
3. What is Einthoven's triangle?
4. List the different methods used to measure blood pressure.
5. Define EEG and list the types of brain waves.
6. What is the principle of EMG?
7. What is the purpose of an isolation amplifier?
8. What is biomedical telemetry?
9. What are the properties of X-rays?
10. What are the different scan modes used in ultrasonic imaging?

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

- 11. a) Explain resting potential and action potential. (7)  
b) Describe different types of bio-potential electrodes. (7)
- 12. a) Explain the Nernst relation and electrode-skin interface. (7)  
b) Describe different bioelectric signals such as ECG, EEG and EMG (7)

**Module II**

- 13. a) Explain the electrical conduction system of the heart. (7)  
b) Describe ECG lead configurations. (7)
- 14. a) Explain the block diagram of an ECG machine. (7)  
b) Explain the auscultatory and oscillometric methods of blood pressure measurement. (7)

**Module III**

- 15. a) Explain the EEG recording system with electrode placement. (7)  
b) Describe the electrical activity of muscles and EMG signal acquisition. (7)
- 16. a) Explain the physiology of the respiratory system. (7)  
b) Describe the working of spirometer and body plethysmograph. (7)

**Module IV**

- 17. a) Explain the working of instrumentation amplifiers used in biomedical instrumentation. (7)  
b) Describe the principle and applications of oximeters. (7)
- 18. a) Explain the working of a cardiac pacemaker. (7)  
b) Describe the biomedical telemetry system and its applications. (7)

**Module V**

- 19. a) Explain the production and properties of X-rays. (7)  
b) Describe the applications of X-rays in medicine. (7)
- 20. a) Explain the principle of ultrasonic imaging systems. (7)  
b) Describe the basic principle and advantages of MRI. (7)

| <b>B24EC4G23</b> | <b>SECURE COMMUNICATION</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF INTRODUCTION</b> |
|------------------|-----------------------------|----------|----------|----------|----------|---------------|-----------------------------|
|                  |                             | 2        | 1        | 0        | 4        |               |                             |

**Preamble**

This course aims to provide an insight into the theory and technology behind secure communication

**Prerequisites**

Nil

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                             |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Apply the concepts of number theory in designing crypto systems.[Apply]                                                                     |
| <b>CO 2</b> | Explain various network security aspects, cryptanalytic attacks and classical cryptosystems.[Understand]                                    |
| <b>CO 3</b> | Illustrate the principles of modern symmetric ciphers like the Data Encryption Standard and Advanced Encryption Standard.[Understand,Apply] |
| <b>CO 4</b> | Apply the principles of asymmetric key cryptosystems and digital signature.[Apply]                                                          |
| <b>CO 5</b> | Discuss various protocols to ensure Email security and Network security.[Understand]                                                        |

**Mapping of Course Outcomes With Program Outcomes**

|             | <b>PO 1</b> | <b>PO 2</b> | <b>PO 3</b> | <b>PO 4</b> | <b>PO 5</b> | <b>PO 6</b> | <b>PO 7</b> | <b>PO 8</b> | <b>PO 9</b> | <b>PO 10</b> | <b>PO 11</b> |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|
| <b>CO 1</b> | 3           |             | 2           |             |             |             |             |             |             |              | 1            |
| <b>CO 2</b> | 1           | 1           | 2           |             |             |             |             |             |             |              | 1            |
| <b>CO 3</b> | 3           | 3           | 2           | 1           |             |             |             |             | 1           |              | 1            |
| <b>CO 4</b> | 3           |             |             |             | 1           |             |             |             |             |              | 1            |
| <b>CO 5</b> | 1           | 2           | 1           |             |             | 2           |             |             |             |              | 1            |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 40                    | 40              | 40                                 |
| Apply            | 40                    | 40              | 40                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Discrete Mathematics for Cryptography:** Integer Arithmetic -Divisibility - Greatest Common Divisor - Extended Euclidean Algorithm- Modular Arithmetic - Modulo Operator - Congruence - Addition and multiplicative inverse, Algebraic structures - Field - Finite fields of the form  $GF(p)$  and  $GF(2^n)$  - Polynomial arithmetic, Prime Numbers - Fermat's and Euler's Theorem

### MODULE 2

**Introduction to Cryptography and Classical Ciphers:** Security Goals, Security Services, Security Mechanisms, Introduction to Cryptography -Classification of Cryptosystems, Cryptanalytic attacks, Cipher Properties - Confusion- Diffusion. Classical Cryptosystems - Substitution Techniques - Monoalphabetic Cipher - Caesar Cipher- Affine Cipher, Polyalphabetic Ciphers - Autokey Cipher- Playfair Cipher-Hill Cipher-Vigenere Cipher- One Time Pad Cipher, Stream and Block Ciphers, Modern Secret Key Ciphers - Substitution Box-Permutation Box-Product Ciphers.

### MODULE 3

**Modern Block Ciphers and Encryption Standards:** Block Cipher Principles – Stream Ciphers and Block Ciphers, Feistel Cipher, Feistel Decryption algorithm, The Data encryption standard, DES Decryption - Avalanche effect, The AES Cipher, substitute bytes transformation, Shift row transformation, Mix Column transformation .

### MODULE 4

**Public Key Systems and Security Protocols:** Public Key Cryptosystems -PKC - Types of PKC – Application for PKC requirements-Trapdoor - One-way functions, RSA Cryptosystem -Key Generation – Encryption- Decryption, ElGamal - Key Generation – Encryption-Decryption, Diffie-Hellman Key Exchange Protocol- Man in the Middle attack on Diffie-Hellman Protocol. Digital Signature- Signing - Verification, Digital signature forgery-Existential forgery- Selective forgery- Universal forgery.

### MODULE 5

**Network Security and Applications:** Symmetric Key Distribution using Symmetric and Asymmetric Encryption - Distribution of public keys -Public announcement- Public

available directory-Public-key authority- Public-key Certificates. Electronic Mail Security -Pretty Good Privacy- PGP message format - Transmission and Reception of PGP Messages, IP Security Overview - IP Authentication Header - Encapsulating Security Payload - Distributed Denial of Service attacks, Secure Electronic Transaction – Payment Processing - Dual Signature, Firewalls - Firewall Design Principles .

**Text Books**

1. Stallings W., Cryptography and Network security: Principles and Practice, 7/e, Pearson Education Asia, 2017
2. Stallings W., Cryptography and Network security: Principles and Practice, 4/e, Pearson Education Asia, 2006
3. Behrouz A Forouzan and DebdeepMukhopadhyay, “Cryptography and Network. Security”, Second Edition, Tata McGraw Hill Education Pvt Ltd Publication, 2010
4. AtulKahate, “Cryptography and Network Security, 4e”, Tata McGraw Hill,2019
5. Bernard Menezes, Network Security and Cryptography-Cengage Learning India, 2011
6. Thomas Mowbray, “Cybersecurity: Managing Systems Conducting Testing, and Investigating Intrusions”, John Wiley, 2014
7. Charles P. Pleegeer, Shari Lawrence Pleegeer, “Security in Computing”, Pearson Education Asia, 5thEdition, 2018
8. Charlie Kaufman, Radia Perlman, Mike Speciner, Network Security: PRIVATE Communication in a PUBLIC World, Pearson Education India, 2016



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                     | No of Lecture/Tutorial Hours |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                           | <b>6</b>                     |
| 1.1 | Integer Arithmetic, Divisibility, GCD.                                                                                                    | 1                            |
| 1.2 | Extended Euclidean Algorithm.                                                                                                             | 1                            |
| 1.3 | Modular Arithmetic, Modulo Operator, Congruence- Addition and Multiplicative Inverse.                                                     | 2                            |
| 1.4 | Algebraic Structures – Fields- Finite Fields GF(p) and GF(2 )- Polynomial arithmetic.                                                     | 1                            |
| 1.5 | Prime Numbers- Fermat's and Euler's Theorem.                                                                                              | 1                            |
|     | <b>Module 2</b>                                                                                                                           | <b>9</b>                     |
| 2.1 | Security Goals, Security Services ,Security Mechanisms.                                                                                   | 1                            |
| 2.2 | Introduction to Cryptography and Classification – Cryptanalytic Attacks and Cipher Properties-Confusion-Diffusion.                        | 2                            |
| 2.3 | Classical Cryptosystems – Substitution Techniques- Monoalphabetic Cipher.                                                                 | 1                            |
| 2.4 | Caesar Cipher- Affine Cipher.                                                                                                             | 1                            |
| 2.5 | Polyalphabetic Cipher-Autokey Cipher- Playfair Cipher.                                                                                    | 1                            |
| 2.6 | Hill Cipher- Vigenere - One Time Pad Cipher.                                                                                              | 2                            |
| 2.7 | Stream and Block Ciphers, Modern secret key ciphers- Substitution Box-Permutation Box-Product Ciphers.                                    | 1                            |
|     | <b>Module 3</b>                                                                                                                           | <b>6</b>                     |
| 3.1 | Block Cipher Principles-Stream Ciphers and Block Ciphers, Feistel Cipher,Feistel Decryption Algorithm.                                    | 2                            |
| 3.2 | The Data Encryption Standard, DES Decryption - Avalanche Effect.                                                                          | 2                            |
| 3.3 | The AES Cipher ,substitute bytes transformation, Shift row transformations, Mix Column transformation.                                    | 2                            |
|     | <b>Module 4</b>                                                                                                                           | <b>6</b>                     |
| 4.1 | Public Key Cryptosystems-PKC-Types of PKC- Application for PKC requirements, Trapdoor-One way functions- RSA Cryptosystem-Key generation. | 2                            |
| 4.2 | Diffie-Hellman Key Exchange protocol – Man in the Middle Attack on Diffie-Hellman Protocol .                                              | 2                            |
| 4.3 | Digital Signature – Signing – Verification- Digital Signature Forgery -Existential forgery-Selective forgery-Universal forgery .          | 2                            |
|     | <b>Module 5</b>                                                                                                                           | <b>8</b>                     |
| 5.1 | Symmetric Key Distribution using Symmetric and Asymmetric Encryption.                                                                     | 1                            |

|     |                                                                                                                           |                 |
|-----|---------------------------------------------------------------------------------------------------------------------------|-----------------|
| 5.2 | Distribution of public keys-Public announcement-Public available directory-Public key authority-Public key certificates.  | 1               |
| 5.3 | Electronic Mail Security - Pretty Good Privacy- PGP message format - Transmission and Reception of PGP Messages .         | 2               |
| 5.4 | IP Security Overview - IP Authentication Header - Encapsulating Security Payload, Distributed Denial of Service attacks . | 2               |
| 5.5 | Secure Electronic Transaction- Payment Processing -Dual Signature.                                                        | 1               |
| 5.6 | Firewalls - Firewall Design Principles.                                                                                   | 1               |
|     | <b>Total Hours</b>                                                                                                        | <b>35 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the role of number theory in cryptography with suitable examples
2. Apply the Euclidean algorithm to find the GCD of two integers and explain its significance in cryptographic key generation

#### Course Outcome 2 (CO 2):

1. Explain the need for network security and discuss its key security goals.
2. Describe different types of cryptanalytic attacks with suitable examples.
3. Explain substitution and transposition ciphers as classical cryptosystems.

#### Course Outcome 3 (CO 3):

1. Explain the structure and working of the Data Encryption Standard (DES).
2. Illustrate the Feistel structure used in symmetric key cryptography.

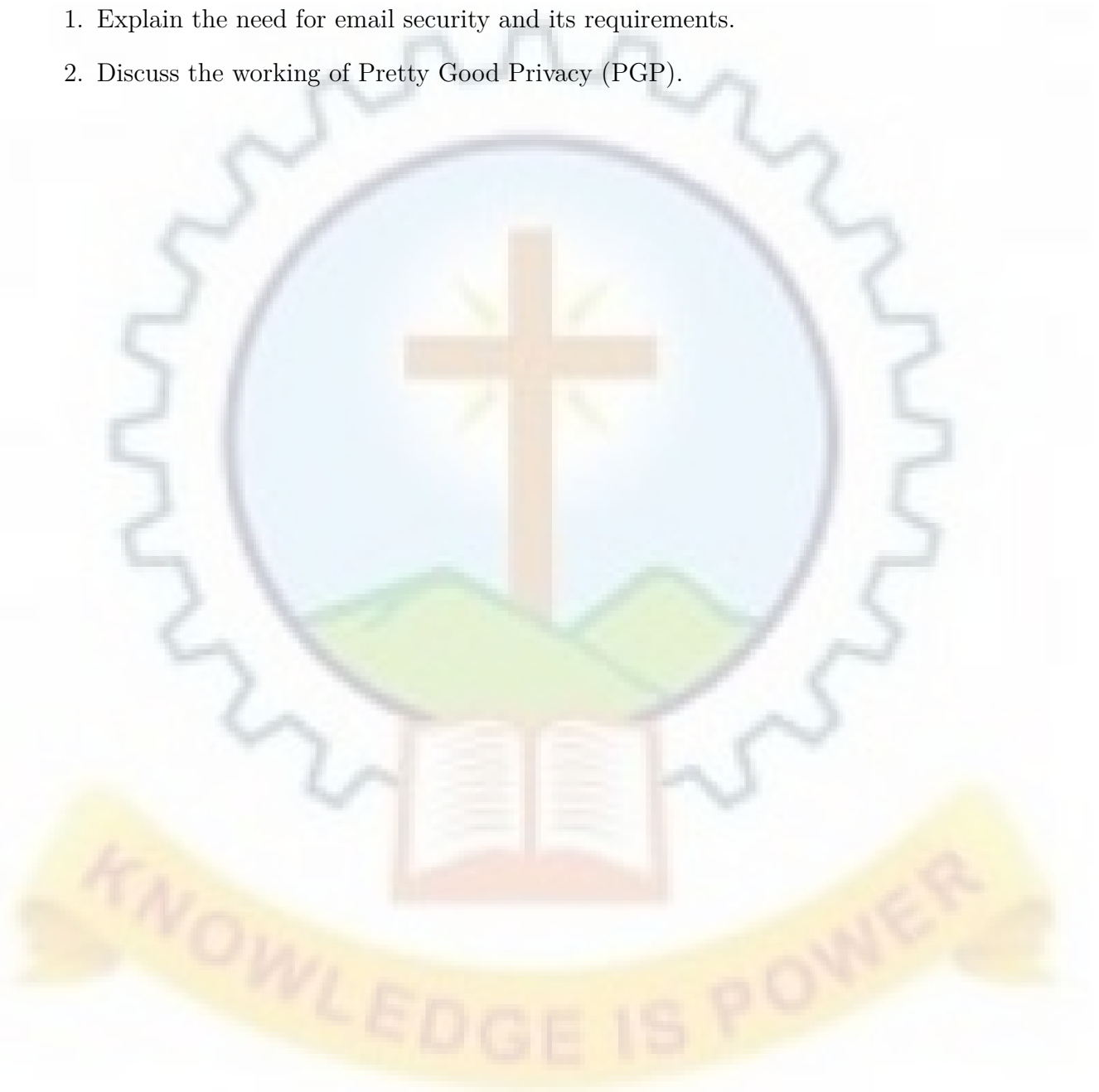
#### Course Outcome 4 (CO 4):

1. Explain the principles of public key cryptography.

2. Describe the RSA algorithm including key generation, encryption, and decryption.
3. Discuss different types of digital signature forgery.

**Course Outcome 5 (CO 5):**

1. Explain the need for email security and its requirements.
2. Discuss the working of Pretty Good Privacy (PGP).



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, NOVEMBER 2027**

**Course Code: B24EC4G23**

**Course Name: SECURE COMMUNICATION**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Identify the number of primes less than 1,000,000.
2. Compute  $33100 \pmod{40}$  (use Euler's theorem).
3. With an example, explain the encryption and decryption process of Caesar Cipher.
4. Compare stream cipher and block cipher with example.
5. Differentiate between diffusion and confusion.
6. Differentiate between block cipher and stream cipher.
7. Consider a Diffie Hellman scheme with a common prime  $q = 11$  and primitive root  $= 2$ . If user A has public key  $Y_A = 9$  and user B has public key  $Y_B = 3$ , estimate A's private key and the shared secret key K between A and B.
8. Explain the requirements for public key cryptography.
9. Discuss about the various types of firewalls.
10. Distinguish between Direct DDoS and Reflector DDoS.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Compute  $\gcd(85, 289)$ . Using Euclid's extended algorithm, obtain  $x$  and  $y$  such that  $85x + 289y = \gcd(85, 289)$ . (7)  
b) Find the particular and general solutions to the equation  $21x + 14y = 35$ . (7)
12. a) Describe the structure of finite fields of the form  $GF(2^n)$ . Explain the role of irreducible polynomials. Construct  $GF(2^3)$  using a suitable irreducible polynomial (14)

**Module II**

13. a) List and explain the security mechanisms defined by X.800. (8)  
b) Illustrate the encryption of given message using Playfair cipher with the keyword "GUIDANCE". Message: MEET ME AT THE TOGA PARTY (6)
14. a) Describe the various cryptanalytic attacks on cryptosystems. (10)  
b) Consider the encryption key in a transposition cipher is  $(3, 2, 6, 1, 5, 4)$ . Determine the corresponding decryption key. (4)

**Module III**

15. a) Describe the internal structure of a single round of DES Encryption algorithm. (8)  
b) In an AES system, given the plaintext 000102030405060708090A0B0C0D0E0F and the key 01010101010101010101010101010101, (i) Show the original contents of State, displayed as a  $4 \times 4$  matrix (ii) Show the value of State after initial Add Round Key Describe the characteristics of the AES Cipher. (6)
16. What are the parameters and design choices that determine the actual algorithm of a Feistel Cipher. Describe Feistel Encryption and Decryption. (14)

**Module IV**

17. a) Illustrate in detail about the message authentication code and its requirements. (7)  
b) Alice and Bob agreed to use RSA algorithm for the secret communication. Alice securely chooses two primes,  $p=5$  and  $q=11$  and a secret key  $d=7$ . Find the corresponding public key. Bob uses this public key and sends a cipher text 18 to Alice. Obtain the plain text. (7)
18. Explain the Diffie-Hellman Key Exchange Protocol. Describe the step-by-step procedure with a numerical example. (14)

**Module V**

19. a) Explain the sequence of steps involved in the message generation and reception in Pretty Good Privacy (PGP) with block diagrams. (10)  
b) Sketch and explain IPSec ESP Format (4)
20. a) Illustrate the working of Secure Electronic Transaction (SET) in detail. (7)  
b) Summarize any two techniques proposed for the distribution of public keys. (7)

| B24EC4G24 | ENTERTAINMENT<br>ELECTRONICS | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|------------------------------|---|---|---|---|--------|-------------------------|
|           |                              | 2 | 1 | 0 | 4 | 3      | 2024                    |

### Preamble

The course aims to provide broad knowledge on various industry standards, algorithms and technologies used to carry out digital audio and video broadcasting in infotainment industry.

### Prerequisites

Nil

### Course Outcomes

After the completion of the course, the student will be able to:

|             |                                                                                                             |
|-------------|-------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand packetized streaming of digital media happens in the field of infotainment industry.             |
| <b>CO 2</b> | Realise the critical aspects of DVB and DAB standards used for media broadcasting in infotainment industry. |
| <b>CO 3</b> | Understand digital audio broadcasting systems                                                               |
| <b>CO 4</b> | Apply video coding/compression algorithms are used to produce high definition video in MPEG-4 standard      |
| <b>CO 5</b> | Understand modern display technologies for video reproduction and future Television System.                 |

### Mapping of Course Outcomes With Program Outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 3    | 2    | 2    | 2    | 1    | 1    |      | 1    |       | 3     |
| <b>CO 2</b> | 3    | 2    | 2    | 2    | 2    | 1    | 1    |      | 1    |       | 3     |
| <b>CO 3</b> | 2    | 2    | 2    | 2    | 2    | 1    | 1    |      | 1    |       | 3     |
| <b>CO 4</b> | 2    | 2    | 2    | 2    | 2    | 1    | 1    |      | 1    |       | 3     |
| <b>CO 5</b> | 2    | 2    | 1    | 2    | 2    | 1    | 1    |      | 1    |       | 1     |



### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 50                    | 50                 | 50                                    |
| Understand       | 50                    | 50                 | 50                                    |
| Apply            |                       |                    |                                       |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Brief Review of Analog Television:** Scanning, Horizontal and Vertical Synchronization, Color information, Transmission methods. NTSC and PAL standards.

**Digital media streaming:** Packetized elementary stream of audio video data, MPEG data stream, MPEG-2 transport stream packet, Accessing a program, scrambled programs, program synchronization. PSI, Additional (Network information and service description) information in data streams for set-top boxes.

### MODULE 2

**Digital Video Broadcasting (DVB):** Satellite TV broadcasting – DVB-S Parameters, DVB-S Modulator, DVB-S set-top box, DVB-S2. Cable TV broadcasting – DVB-C Standard, DVB-C Modulator, DVB C set-top box. Terrestrial TV broadcasting – DVB-T Standard, DVB-T Modulator, DVB-T Carriers and System Parameters, DVB-T receiver. Broadcasting for Handheld devices – DVB-H Standard DVB tele-text, DVB subtitling system.

### MODULE 3

**Digital Audio Broadcasting (DAB):** Comparison of DAB with DVB. Physical layer of DAB. DAB Modulator, DAB Data Structure, DAB single frequency networks, Data broadcasting using DAB. Digital Radio Mondiale (DRM): Transmitter and receiver, Data rates.

### MODULE 4

**High Definition Video and Audio:** Pixel resolution, Comparison with Standard Definition TV, Review of Discrete Cosine Transforms (DCT), Video Compression - Quantization levels, Horizontal/Vertical blanking interval, Vertical Color resolution, DPCM of moving pictures, DCT, Run-length coding. MPEG-4 Video coding. Psycho-acoustic model, Principle of audio coding, Sub-band coding in MPEG layer 1 and 2, MPEG Layer 3 and Dolby Digital, Multichannel sound.

### MODULE 5

**Display Technology:** Block diagram of video reproduction system in a TV, Cathode Ray tubes, Basic principle of Plasma displays, LC displays, Light-emitting diode displays,

Field emission displays, Organic light emitting device displays.

**Television of future:** Holographic TV, Virtual Reality, Augmented Reality.

**Text Books**

1. W. Fischer, Digital Video and Audio Broadcasting Technology: A Practical Engineering Guide (Signals and Communication Technology), Springer, 2020
2. Lars-Ingemar Lundström, Understanding Digital Television An Introduction to DVB Systems with Satellite, Cable, Broadband and Terrestrial TV, Focal Press, Elsevier, 2006.
3. K F Ibrahim, Newnes Guide to Televeision and Video Technology, Newnes, 2007.
4. Jiun-Haw Lee, David N. Liu, Shin-Tson Wu, Introduction to Flat Panel Displays, Wiley, 2008.



**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                         | <b>No of Lecture/Tutorial Hours</b> |
|-----------|----------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                                      | <b>7</b>                            |
| 1.1       | Analog Television, Scanning, Horizontal and Vertical Synchronization, Colour information, NTSC and PAL standards.    | 2                                   |
| 1.2       | Analog TV Transmission                                                                                               | 1                                   |
| 1.3       | Packetized elementary stream. MPEG data stream, MPEG-2 transport stream packet                                       | 2                                   |
| 1.4       | Accessing a program, scrambled programs, program synchronization. Program Specific Information                       | 1                                   |
| 1.5       | Additional (Network information and service description) information in data streams                                 | 1                                   |
|           | <b>Module 2</b>                                                                                                      | <b>7</b>                            |
| 2.1       | Introduction to DVB, DVB-S Parameters, DVB-S Modulator, DVB-S set-top box, DVB-S2.                                   | 2                                   |
| 2.2       | DVB-C Standard, DVB-C Modulator, DVB-C set-top box.                                                                  | 1                                   |
| 2.3       | DVB-T Standard, DVB-T Modulator, DVB-T Carriers and System Parameters, DVB-T receiver.                               | 2                                   |
| 2.4       | Broadcasting for Handheld devices – DVB-H Standard                                                                   | 1                                   |
| 2.5       | DVB teletext, DVB subtitling system.                                                                                 | 1                                   |
|           | <b>Module 3</b>                                                                                                      | <b>8</b>                            |
| 3.1       | Introduction to DAB, Comparison of DAB with DVB.                                                                     | 2                                   |
| 3.2       | Physical layer of DAB. DAB Modulator, DAB Data Structure                                                             | 2                                   |
| 3.3       | DAB single frequency networks, Data broadcasting using DAB.                                                          | 2                                   |
| 3.4       | Digital Radio Mondiale (DRM): Transmitter and receiver, Data rates.                                                  | 2                                   |
|           | <b>Module 4</b>                                                                                                      | <b>8</b>                            |
| 4.1       | HDTV versus SDTV, Pixel resolution, Review of Discrete Cosine Transforms (DCT)                                       | 2                                   |
| 4.2       | Video Compression - Quantization levels, Horizontal/Vertical blanking interval, Vertical Colour resolution,          | 2                                   |
| 4.3       | DPCM of moving pictures, DCT, Run-length and Huffman coding. MPEG-4. Psychoacoustic model, Principle of audio coding | 2                                   |
| 4.4       | Subband coding in MPEG layer 1 and 2. MPEG Layer 3 and Dolby Digital, Multichannel sound                             | 2                                   |
|           | <b>Module 5</b>                                                                                                      | <b>8</b>                            |
| 5.1       | Block diagram of video reproduction system in a TV                                                                   | 1                                   |
| 5.2       | Cathode Ray tubes                                                                                                    | 2                                   |

|     |                                                                                                                                                  |                 |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 5.3 | Basic principle of Plasma displays, LC displays, Light-emitting diode displays, Field emission displays, Organic light emitting device displays. | 2               |
| 5.4 | Holographic TV, Virtual Reality, Augmented Reality.                                                                                              | 2               |
|     | <b>Total Hours</b>                                                                                                                               | <b>38 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain packetized streaming of digital media happens in the field of infotainment industry.
2. Discuss MPEG-2 standards for streaming multimedia data and aspects of synchronization, accessing scrambled programs and program synchronization.

#### Course Outcome 2 (CO 2):

1. Discuss the critical aspects of DVB and DAB standards used for media broadcasting in infotainment industry.
2. Describe the existing standards and features for modulation and demodulation schemes related with DAB, various types of DVB and DRM.

#### Course Outcome 3 (CO 3):

1. Explain Physical layer of DAB .Working of DAB modulator.
2. Understanding the working of Digital Radio Mondiale.

#### Course Outcome 4 (CO 4):

1. Explain how the video coding/compression algorithms are used to produce high-definition video in MPEG-4 standard.
2. Understanding quantization, DCT, differential PCM for MPEG-4 video compression.

#### Course Outcome 5 (CO 5):

1. Discuss modern display technologies for video reproduction.
2. Explain the basic principles of video reproduction and display technology such as CRT, LCD, plasma and OLED

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2028**

**Course Code: B24EC4G24**

**Course Name: ENTERTAINMENT ELECTRONICS**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Explain horizontal and vertical synchronization in analog television systems
2. What is an MPEG-2 transport stream packet? Explain its structure briefly.
3. List the key parameters of DVB-S system.
4. What is DVB-H? Mention its applications.
5. Compare DAB and DVB broadcasting systems.
6. What is Digital Radio Mondiale (DRM)? Mention its advantages.
7. What is Discrete Cosine Transform (DCT)? State its role in video compression.
8. Define quantization in video compression.
9. Draw and explain the block diagram of a video reproduction system in TV.
10. State the basic principle of OLED display.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**



11. a) Explain scanning process in analog television. Compare NTSC and PAL standards. (7)  
b) Describe the structure of MPEG data streams and packetized elementary streams used in digital media streaming. (7)
12. a) Explain accessing a program in MPEG-2 transport stream. Discuss scrambled programs and program synchronization. (7)  
b) Discuss Program Specific Information (PSI) and additional network/service information used in set-top boxes. (7)

**Module II**

13. a) Explain DVB-S system with block diagram of DVB-S modulator and set-top box. (7)  
b) Describe DVB-C standard and its modulation techniques. (7)
14. a) Explain DVB-T standard, carriers, and system parameters with suitable diagram. (7)  
b) Discuss DVB teletext and DVB subtitling system in detail. (7)

**Module III**

15. a) Explain the physical layer of DAB with neat diagram. (7)  
b) Describe DAB modulator and DAB data structure in detail. (7)
16. a) Explain Single Frequency Network (SFN) in DAB and its advantages. (7)  
b) Describe DRM transmitter and receiver system with data rates. (7)

**Module IV**

17. a) Compare HDTV and SDTV in terms of resolution and performance. (7)  
b) Explain MPEG-4 video compression process including DCT, quantization, DPCM and run-length coding (7)
18. a) Discuss psychoacoustic model and principle of audio coding. (7)  
b) Explain sub-band coding in MPEG Layer 1 & 2 and MPEG Layer 3 (MP3). Add notes on Dolby Digital and multichannel sound. (7)

**Module V**

19. a) Explain the working principle of Cathode Ray Tube (CRT) with diagram. (7)  
b) Describe the basic principle and construction of Plasma and LCD displays (7)
20. a) Compare LED, Field Emission Display (FED), and OLED technologies. (7)  
b) Discuss future television technologies: Holographic TV, Virtual Reality, and Augmented Reality. (7)

| B24EC4G25 | DIGITAL IMAGE PROCESSING | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|--------------------------|---|---|---|---|--------|----------------------|
|           |                          | 2 | 1 | 0 | 4 | 3      | 2024                 |

### Preamble

This course introduces the fundamental concepts and techniques of Digital Image Processing, focusing on image representation, enhancement, compression, segmentation and restoration.

### Prerequisites

B24EC2T05 : SIGNALS AND SYSTEM

### Course Outcomes

After completing the course, students will gain knowledge of both spatial domain and frequency domain techniques used to improve image quality and extract useful information from images. The course introduces practical methods such as image filtering, edge detection, transform techniques, and image compression standards. By the end of the course, students will be able to understand and apply fundamental image processing algorithms for the analysis, enhancement, and interpretation of digital images.

|      |                                                                                                                                                |
|------|------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Explain the fundamentals of digital images, image representation, colour models, and basic relationships between pixels. (Understand)          |
| CO 2 | Apply spatial domain techniques such as gray level transformations, histogram processing, and spatial filtering for image enhancement. (Apply) |
| CO 3 | Apply frequency domain transforms and filtering techniques for image enhancement and image compression. (Apply)                                |
| CO 4 | Apply basic image segmentation techniques including edge detection, region-based methods, and thresholding to analyze images. (Apply)          |
| CO 5 | Apply image restoration and geometric transformation techniques to improve degraded images. (Apply)                                            |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 1    |      |      | 1    |      |      |      |      |       | 1     |
| CO 2 | 2    | 2    |      | 1    | 3    |      |      |      |      |       | 1     |
| CO 3 | 2    | 2    |      | 1    | 3    |      |      |      |      |       | 1     |
| CO 4 | 2    | 2    | 1    | 1    | 3    |      |      |      |      |       | 1     |
| CO 5 | 2    | 2    | 1    | 1    | 3    |      |      |      |      |       | 1     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 30                    | 30                 | 30                                    |
| Apply            | 50                    | 50                 | 50                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Introduction to Digital Image Processing:** Introduction to images and types of images, applications of digital image processing in various fields, fundamental steps in image processing, image characteristics such as brightness, contrast, hue, saturation, and Mach band effect, 2D image sampling and quantization, and basic pixel relationships including neighbors, connectivity, and distance measures between pixels. Colour image fundamentals- RGB, CMY, HIS models.

### MODULE 2

**Image Enhancement in the Spatial Domain:** Basic Gray Level Transformations, Histogram Processing, Enhancement Using Arithmetic and Logic operations, Basics of Spatial Filters, Smoothing Spatial Filters: Low pass filters, Order Statistics filters; Sharpening Spatial Filters: Laplacian filter

### MODULE 3

**Image Enhancement in the Frequency Domain:** 2D Image transforms: DFT, its properties, Walsh transform, Hadamard transform, Haar transform . Frequency Domain Filtering: Ideal and Butterworth Low pass and High pass filters, Homomorphic Filtering.

**Image Compression** Need for Image Compression , Redundancy in Images, Classification of Redundancy in Images , Image Compression Scheme, Classification of Image Compression Schemes ,Transform Based Compression, JPEG 2000 Standards.

### MODULE 4

**Image segmentation: Classification of Image segmentation techniques:** Point, Line and Edge Detection, Gradient and Laplacian based edge detection, Region approach, Segmentation based on thresholding (global and adaptive ) ,clustering techniques, hough transform, canny edge detection.

### MODULE 5

**Image Restoration:** Degradation model, Unconstraint restoration- Lagrange multiplier and constraint restoration Inverse filtering- removal of blur caused by uniform linear motion, Wiener filtering, Geometric transformations-spatial transformations.

### Text Books

1. Digital Image Processing, Gonzalez Rafael C, Pearson Education, 2009
2. Digital image processing, S Jayaraman, S Esakkirajan, T Veerakumar, Tata Mc Graw Hill, 2015
3. Fundamentals of Digital Image Processing ,Anil K. Jain Prentice-Hall of India

4. Digital Image Processing Using MATLAB Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins
5. Computer Vision: Algorithms and Applications, Richard Szeliski Springer
6. Digital image processing: Kenneth R Castleman, Pearson Education, 2/e, 2003



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                          | No of Lecture/Tutorial Hours |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                | <b>6</b>                     |
| 1.1 | Introduction to images and types of images, applications of digital image processing in various fields, fundamental steps in image processing. | 1                            |
| 1.2 | fundamental steps in image processing, elements of digital image processing systems.                                                           | 1                            |
| 1.3 | image characteristics such as brightness, contrast, hue, saturation, and Mach band effect.                                                     | 2                            |
| 1.4 | 2D image sampling and quantization, and basic pixel relationships including neighbors, connectivity, and distance measures between pixel       | 1                            |
| 1.5 | Colour image fundamentals-RGB, CMY, HIS models.                                                                                                | 1                            |
|     | <b>Module 2</b>                                                                                                                                | <b>8</b>                     |
| 2.1 | Basic Gray Level Transformations.                                                                                                              | 2                            |
| 2.2 | Histogram Processing.                                                                                                                          | 1                            |
| 2.3 | Enhancement Using Arithmetic and Logic operations.                                                                                             | 1                            |
| 2.4 | Basics of Spatial Filters.                                                                                                                     | 1                            |
| 2.5 | Smoothing Spatial Filters: Low pass filters, Order Statistics filters.                                                                         | 2                            |
| 2.6 | Sharpening Spatial Filters: Laplacian filter.                                                                                                  | 1                            |
|     | <b>Module 3</b>                                                                                                                                | <b>9</b>                     |
| 3.1 | 2D Image transforms: DFT, its properties.                                                                                                      | 2                            |
| 3.2 | Walsh transform, Hadamard transform, Haar transform.                                                                                           | 2                            |
| 3.3 | Frequency Domain Filtering: Ideal and Butterworth Low pass and High pass filters.                                                              | 1                            |
| 3.4 | Homomorphic Filtering.                                                                                                                         | 1                            |
| 3.5 | Image Compression Need for Image Compression , Redundancy in Images, Classification of Redundancy in Images .                                  | 1                            |
| 3.6 | Image Compression Scheme, Classification of Image Compression Schemes .                                                                        | 1                            |
| 3.7 | Transform Based Compression, JPEG 2000 Standards.                                                                                              | 1                            |
|     | <b>Module 4</b>                                                                                                                                | <b>7</b>                     |
| 4.1 | Classification of Image segmentation techniques. Point, Line and Edge Detection                                                                | 1                            |
| 4.2 | Gradient and Laplacian based edge detection                                                                                                    | 1                            |
| 4.3 | Region approach, Segmentation based on thresholding.                                                                                           | 2                            |
| 4.4 | Segmentation based on thresholding (global and adaptive )                                                                                      | 1                            |
| 4.5 | clustering techniques, houghtransform, canny edge detection.                                                                                   | 2                            |



|     | <b>Module 5</b>                                                                 | <b>6</b>        |
|-----|---------------------------------------------------------------------------------|-----------------|
| 5.1 | Degradation model.                                                              | 1               |
| 5.2 | Unconstrained restoration- Lagrange multiplier and constraint restoration       | 1               |
| 5.3 | restoration Inverse filtering- removal of blur caused by uniform linear motion. | 2               |
| 5.4 | Weiner filtering. Geometric transformations-spatial transformations             | 2               |
|     | <b>Total Hours</b>                                                              | <b>36 Hours</b> |

### **CO ASSESSMENT QUESTIONS**

#### **Course Outcome 1 (CO 1):**

1. Explain the process of image sampling and quantization and illustrate how they affect digital image representation.
2. Describe the basic relationships between pixels such as adjacency, connectivity, and distance measures used in digital image processing.
3. Compare the RGB, CMY, and HSI colour models and explain their applications in digital image processing.

#### **Course Outcome 2 (CO 2):**

1. Explain different gray level transformation techniques used for image enhancement with suitable examples.
2. Describe histogram processing techniques and explain how histogram equalization improves image contrast.
3. Apply spatial filtering techniques such as smoothing and sharpening filters for image enhancement.

#### **Course Outcome 3 (CO 3):**

1. Explain the concept of 2-D Discrete Fourier Transform (DFT) and its role in frequency domain image processing.
2. Apply frequency domain filters such as ideal, Butterworth, and Gaussian filters for image enhancement.

3. Explain the need for image compression and describe transform-based compression techniques such as JPEG.

**Course Outcome 4 (CO 4):**

1. Explain different image segmentation techniques such as point detection, line detection, and edge detection.
2. Discuss gradient-based and Laplacian-based edge detection methods. Explain how these techniques help identify object boundaries in an image.
3. Explain threshold-based image segmentation. Differentiate between global and adaptive thresholding, and briefly discuss clustering techniques, Hough transform, and Canny edge detection.

**Course Outcome 5 (CO 5):**

1. Explain the image degradation model used in image restoration.
2. Apply inverse filtering and Wiener filtering techniques for restoring degraded images.
3. Explain geometric transformations and their role in spatial image transformation.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24EC4G25**

**Course Name: DIGITAL IMAGE PROCESSING**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Why are pixels fundamental in the representation of digital images, and how do they contribute to the basic structure of an image?.
2. Explain the Mach Band effect and its significance in visual perception..
3. Explain histogram equalization.
4. What are Laplacian and Sobel operators? State their uses.
5. Discuss any three properties of the Discrete Fourier Transform and its importance in image processing..
6. Explain the concept of transform coding in image compression. How does it contribute to reducing redundancy in image data?
7. What is Canny edge detector? List its major steps.
8. Illustrate the use of derivative operation in edge detection.
9. Mention three factors that can lead to the deterioration of image quality.
10. In which condition does the Wiener filter transform into an inverse filter? Explain.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Elaborate on the importance of 2D sampling in digital image processing and discuss the process of quantization (8)  
b) Define the terms brightness, contrast and hue with respect to digital images. (6)
12. a) Discuss the conceptual relationship between the RGB and HIS colour models with neat sketches. (10)  
b) Differentiate between spatial resolution and intensity resolution. (4)

**Module II**

13. a) Explain the concept of image averaging in spatial domain methods. Discuss its role in reducing noise and enhancing image quality. Provide examples and discuss the limitations of image averaging. (7)  
b) Compute the 2-D DFT of a  $2 \times 2$  matrix given

$$x[m, n] = \begin{bmatrix} 125 & 237 \\ 342 & 189 \end{bmatrix}$$

14. a) Perform histogram equalization of the following image

| Gray-level value               | 0  | 1 | 2 | 3 | 4  | 5 | 6 | 7 |
|--------------------------------|----|---|---|---|----|---|---|---|
| No. of Pixel (Histogram value) | 10 | 8 | 9 | 2 | 14 | 1 | 5 | 2 |

- b) Explain the point operations used in image enhancement.

**Module III**

15. a) Illustrate the algorithmic steps to generate Haar basis. . (7)  
b) Construct a Walsh-Hadamard Transform Matrix for an order of 4. Write down the elements of the matrix in their respective rows and columns. (7)
16. a) Explain how the JPEG image compression standard utilizes transform coding. Discuss the key components and processes involved in the JPEG compression algorithm. (7)  
b) Explain the steps involved in homomorphic filtering. (7)

**Module IV**

17. a) Explain region splitting and merging in image segmentation with neat schematics. (8)  
b) Discuss Canny edge detection in detail. (6)
18. a) Explain the method of global thresholding for image segmentation (7)  
b) Explain the use of Hough transform for line detection. (7)

**Module V**

19. a) Explain the concept of a degradation model in image restoration. Discuss how it represents the relationship between the original and degraded images. (7)  
b) Explain image restoration using inverse filtering techniques. Give its limitations.
20. a) Discuss the Wiener filtering technique in image restoration. Explain how it considers both the characteristics of the image and the noise to enhance the. (7)  
b) Explain the various geometric transformations. (7)

|           |                                           |   |   |   |   |        |                      |
|-----------|-------------------------------------------|---|---|---|---|--------|----------------------|
| B24HU4T04 | DISASTER MANAGEMENT AND INDUSTRIAL SAFETY | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|           |                                           | 2 | 1 | 0 | 4 | 3      |                      |

### Preamble

This course explains how disasters happen and how to reduce risk through planning, preparedness, response, and recovery. It also covers industrial safety identifying hazards, using basic assessment tools, and applying safety rules to prevent accidents.

**Prerequisites:** Nill

### Course Outcomes

After the completion of the course, the student will be able to:

|      |                                                                                                                                   |
|------|-----------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Understand the fundamental concepts, classifications, and phases of the disaster management cycle and their impacts on society.   |
| CO 2 | Apply remote sensing resolutions and risk analysis concepts to identify and predict hazards at various administrative levels.     |
| CO 3 | Utilize hazard identification techniques like HAZOP and FMEA to assess industrial risks and causation theories.                   |
| CO 4 | Analyze industrial safety standards, fire safety protocols, and statutory provisions like the Factories Act and OSHA.             |
| CO 5 | Evaluate ethical responsibilities and lessons from historical case studies to develop sustainable disaster prevention strategies. |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 2    | 2    | 1    |      |      | 3    |      |      |      |       | 1     |
| CO 2 | 3    | 3    | 2    | 2    | 3    | 1    |      |      |      |       | 1     |
| CO 3 | 3    | 3    | 3    | 2    | 2    | 2    | 1    | 2    |      |       | 1     |
| CO 4 |      |      | 1    |      |      | 3    | 2    | 2    | 3    | 2     | 1     |
| CO 5 | 1    | 2    | 2    | 1    |      | 3    | 3    |      | 2    |       | 2     |



### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 10                 | 10                                    |
| Understand       | 30                    | 20                 | 20                                    |
| Apply            | 30                    | 25                 | 25                                    |
| Analyse          | 20                    | 25                 | 20                                    |
| Evaluate         |                       | 20                 | 15                                    |
| Create           |                       |                    | 10                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |            |
|----------------------------------------|------------|
| Attendance                             | : 10 marks |
| Continuous Assessment Test (2 numbers) | : 25 marks |
| Assignment/Quiz/Course Project         | : 10 marks |
| Self - Learning                        | : 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions.

## **SYLLABUS**

### **MODULE 1: Introduction to Disaster Management (8 hours)**

Disaster: definition, scope, and importance. Classification of disasters: natural and man-made. Natural disasters: earthquake, flood, cyclone, drought, landslide, tsunami – causes and effects. Man-made disasters: industrial accidents, chemical disasters, nuclear disasters, fire hazards – Impacts of disasters on human life, infrastructure, economy, and environment. Disaster management cycle: prevention, mitigation, preparedness, response, recovery.

### **MODULE 2: Disaster Preparedness, Mitigation, and Response (8 hours)**

Disaster risk reduction concepts. Hazard, vulnerability, and risk analysis. Disaster preparedness planning at community, district, state, and national levels. Early warning systems and forecasting methods. Emergency response planning, evacuation procedures, and shelter management. Role of government agencies (NDMA, SDMA, DDMA).

### **MODULE 3: Industrial Safety and Hazard Identification (7 Hours)**

Introduction to industrial safety and accident prevention. Types of industrial hazards: mechanical, electrical, chemical, biological, radiation, ergonomic. Causes of industrial accidents and accident causation theories. Hazard identification techniques: HAZOP, FMEA. Safety management systems and safety culture. Risk assessment and control measures.

Safety legislation and statutory provisions – Hearing Conservation Programme: Principles, implementation and monitoring. Fire safety: causes of fire, fire prevention, detection, and fire-fighting systems – Electrical safety and machine guarding – Personal Protective Equipment (PPE): types, selection, and usage.

### **MODULE 4: Industrial Safety Practices and Legislation (7 Hours)**

Safety legislation and statutory provisions – Hearing Conservation Programme: Principles, implementation and monitoring. Fire safety: causes of fire, fire prevention, detection, and fire-fighting systems – Electrical safety and machine guarding – Personal Protective Equipment (PPE): types, selection, and usage.

### **MODULE 5: Environmental Safety, Case Studies (6 Hours)**

Environmental pollution due to industrial activities – Solid, liquid, and hazardous waste management – Sustainable industrial safety practices – Case studies: Bhopal Gas Tragedy, Chernobyl Nuclear Disaster, Fukushima Disaster – Lessons learned and preventive strategies.

### **Text Books**

1. Disaster Management — Harsh K. Gupta. Universities Press (Orient Black swan), 2003. ISBN: 9788173714566.
2. Remote Sensing of the Environment: An Earth Resource Perspective — John R. Jensen. 2nd Edition, Pearson Prentice Hall, Upper Saddle River, NJ, 2007. ISBN: 9780131889507.
3. Fundamentals of Industrial Safety and Health (Vol. 1 & 2) — K. U. Mistry. 4th Edition, Siddharth, 2022.

### **References**

1. Harsh K. Gupta, “Disaster Management”, Universities Press.
2. Thomas M. Lillesand, Ralph W. Kiefer, Jonathan W. Chipman, “Remote Sensing and Image Interpretation”, Wiley.
3. R. K. Jain, Sunil S. Rao, “Industrial Safety, Health and Environment Management Systems”, Khanna Publishers.
4. Roger L. Brauer, “Safety and Health for Engineers”, Wiley.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                                                                                                     | <b>No of Lecture/- Tutorial Hours</b> |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
|           | <b>Module 1</b>                                                                                                                                                                                  | <b>8</b>                              |
| 1.1       | Disaster: definition, scope, and importance. Classification of disasters: natural and man-made. Natural disasters: earthquake, flood, cyclone, drought, landslide, tsunami – causes and effects. | 2                                     |
| 1.2       | Man-made disasters: industrial accidents, chemical disasters, nuclear disasters, fire hazards.                                                                                                   | 1                                     |
| 1.3       | Impacts of disasters on human life, infrastructure, economy, and environment.                                                                                                                    | 2                                     |
| 1.4       | Disaster management cycle: prevention, mitigation, preparedness, response, recovery.                                                                                                             | 2                                     |
|           | <b>Module 2</b>                                                                                                                                                                                  | <b>8</b>                              |
| 2.1       | Disaster risk reduction concepts. Hazard, vulnerability, and risk analysis.                                                                                                                      | 2                                     |
| 2.2       | Disaster preparedness planning at community, district, state, and national levels.                                                                                                               | 2                                     |
| 2.3       | Early warning systems and forecasting methods.                                                                                                                                                   | 2                                     |
| 2.4       | Emergency response planning, evacuation procedures, and shelter management                                                                                                                       | 1                                     |
| 2.5       | Role of government agencies (NDMA, SDMA, DDMA)                                                                                                                                                   | 1                                     |
|           | <b>Module 3</b>                                                                                                                                                                                  | <b>7</b>                              |
| 3.1       | Introduction to industrial safety and accident prevention. Types of industrial hazards: mechanical, electrical, chemical, biological, radiation, ergonomic.                                      | 2                                     |
| 3.2       | Causes of industrial accidents and accident causation theories.                                                                                                                                  | 1                                     |
| 3.3       | Hazard identification techniques: HAZOP, FMEA, Fault Tree Analysis.                                                                                                                              | 2                                     |
| 3.4       | Safety management systems and safety culture. Risk assessment and control measures.                                                                                                              | 2                                     |
|           | <b>Module 4</b>                                                                                                                                                                                  | <b>7</b>                              |
| 4.1       | Safety Legislation & Statutory Provisions Hearing Conservation Programme                                                                                                                         | 2                                     |
| 4.2       | Fire Safety Fundamentals.                                                                                                                                                                        | 1                                     |
| 4.3       | Fire-Fighting Systems and Electrical Safety.                                                                                                                                                     | 2                                     |
| 4.4       | Machine Guarding & Personal Protective Equipment (PPE)                                                                                                                                           | 2                                     |
|           | <b>Module 5</b>                                                                                                                                                                                  | <b>6</b>                              |
| 5.1       | Environmental pollution due to industrial activities – Solid, liquid, and hazardous waste management                                                                                             | 1                                     |

|     |                                                                                                                               |                 |
|-----|-------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 5.2 | Sustainable industrial safety practices – Ethical responsibilities of engineers in disaster prevention and industrial safety. | 2               |
| 5.3 | Case studies: Bhopal Gas Tragedy, Chernobyl Nuclear Disaster, Fukushima Disaster.                                             | 2               |
| 5.4 | Lessons learned and preventive strategies.                                                                                    | 1               |
|     | <b>Total Hours</b>                                                                                                            | <b>36 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Define “disaster” and classify disasters into natural and man-made categories. Explain with suitable examples relevant to civil infrastructure.
2. Explain the Disaster Management Cycle (DMC) and discuss how each phase (prevention, mitigation, preparedness, response, recovery) reduces impacts on human life, infrastructure, economy, and environment.

#### Course Outcome 2 (CO 2):

1. A district experiences repeated flooding. Using the concept  $\text{Risk} = \text{Hazard} \times \text{Vulnerability}$ , explain how you would identify high-risk zones and prioritize mitigation measures at community and district levels.
2. Explain spatial, spectral, temporal, and radiometric resolutions in remote sensing. For each, mention one disaster-management application (flood/cyclone/landslide monitoring).

#### Course Outcome 3 (CO 3):

1. In a chemical storage facility, outline the steps to perform a HAZOP study and demonstrate how deviations (e.g., “more pressure”, “less flow”) can lead to accident scenarios.
2. Perform an FMEA framework for an industrial system (any one: boiler, conveyor belt, electrical panel, solvent storage tank): identify failure modes, effects, severity/occurrence/detection, and suggest controls.

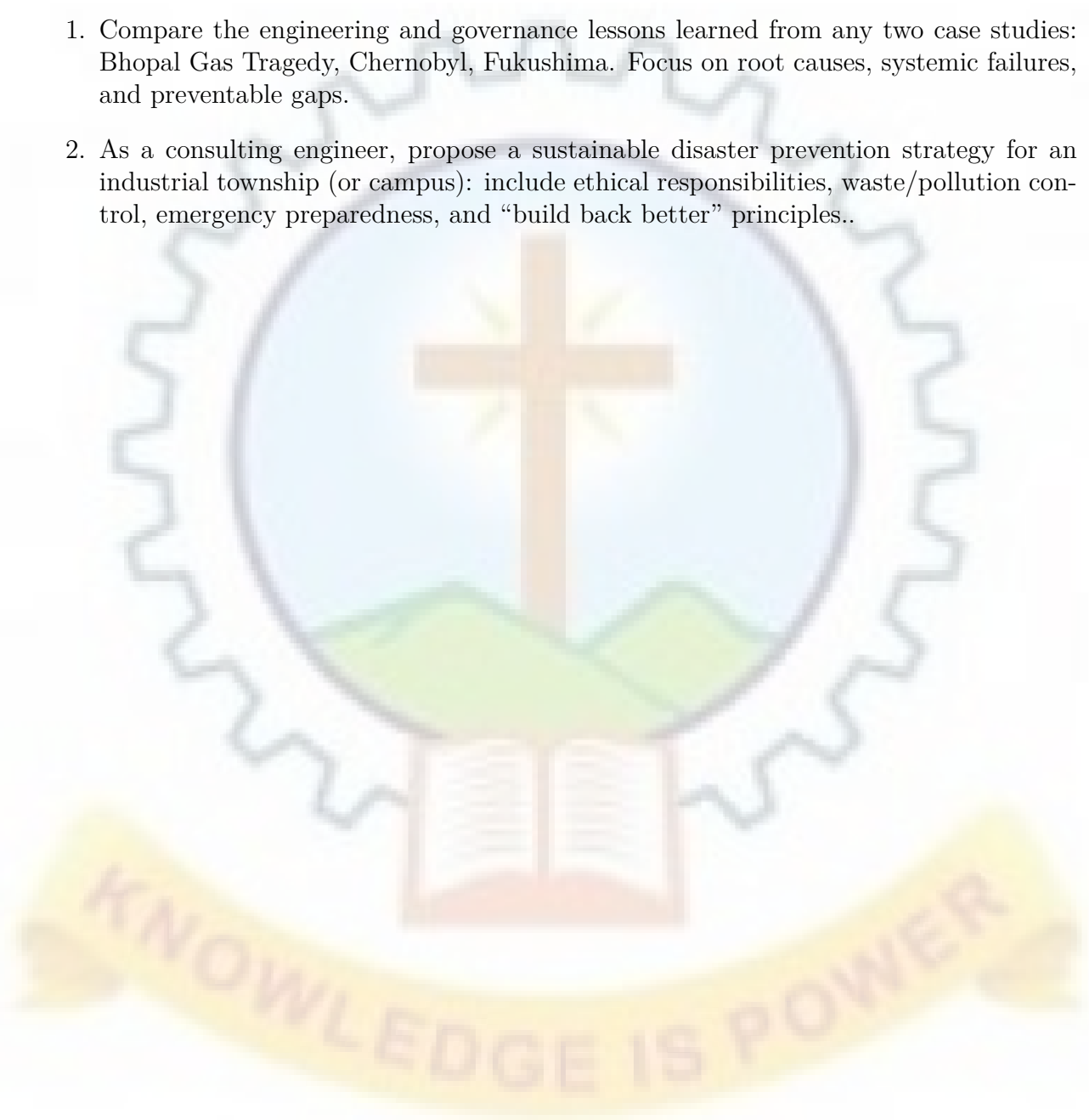
#### Course Outcome 4 (CO 4):

1. Discuss key provisions of the Factories Act related to safety, health, and welfare. Explain how statutory compliance improves industrial safety performance.

2. For an industrial workshop/lab building, prepare a fire safety and electrical safety plan covering fire triangle, detection & suppression systems, safe evacuation, LOTO concept, and machine guarding.

**Course Outcome 5 (CO 5):**

1. Compare the engineering and governance lessons learned from any two case studies: Bhopal Gas Tragedy, Chernobyl, Fukushima. Focus on root causes, systemic failures, and preventable gaps.
2. As a consulting engineer, propose a sustainable disaster prevention strategy for an industrial township (or campus): include ethical responsibilities, waste/pollution control, emergency preparedness, and “build back better” principles..





**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 2**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, 2027**

**Course Code: B24HU4T04**

**Course Name: DISASTER MANAGEMENT AND INDUSTRIAL SAFETY**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define disaster and explain the scope and importance of disaster management.
2. Classify disasters into natural and man-made and list any three examples of each.
3. Define hazard, vulnerability, and risk and write the relation between them.
4. List the roles of NDMA, SDMA, and DDMA in disaster preparedness and response.
5. List any six industrial hazards and give one example for each (mechanical/electrical/-chemical etc.).
6. Differentiate HAZOP and FMEA (any three points).
7. State any three key safety provisions of the Factories Act related to health and welfare.
8. Explain the fire triangle and list any three fire prevention measures in industries.
9. List types of industrial wastes (solid/liquid/hazardous) and mention one safe disposal method for each.
10. Write any three ethical responsibilities of engineers in disaster prevention and industrial safety.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain the causes and effects of any two natural disasters  
b) Explain the Disaster Management Cycle and describe how each phase reduces impacts.

OR

12. a) Explain man-made disasters with reference to industrial accidents/chemical/nuclear/fire hazards causes and impacts.  
b) Explain spatial, spectral, temporal, and radiometric resolutions and mention one application of each in disaster studies.

**Module II**

13. a) Explain Disaster Risk Reduction (DRR) and describe risk analysis using hazard-vulnerability concepts.  
b) Prepare a community-level disaster preparedness plan (key components and steps).

OR

14. a) Explain early warning systems and forecasting methods for any one hazard.  
b) Describe evacuation procedures and shelter management for a district-level emergency.

**Module III**

15. a) Explain accident causation theories and discuss common causes of industrial accidents.  
b) Explain safety management system and elements of safety culture with suitable measures.

OR

16. a) Conduct a HAZOP outline for a chemical storage/processing unit: nodes, deviations, causes, consequences, safeguards.  
b) Prepare an FMEA for an industrial system (any one: electrical panel/boiler/-conveyor/solvent tank): failure modes, effects, and controls.

**Module IV**

17. a) Discuss major Factories Act provisions for safety, health, and welfare with examples.  
b) Explain OSHA principles and how they improve workplace safety performance.

OR

18. a) Explain fire detection and fire-fighting systems (alarms, extinguishers, hydrants/sprinklers) and a basic emergency plan.
- b) Explain electrical safety and machine guarding, and discuss PPE types, selection, and correct usage.

**Module V**

19. a) Explain industrial pollution pathways and describe solid, liquid and hazardous waste management practices.
- b) Explain sustainable industrial safety practices and the ethical role of engineers in prevention.

OR

20. a) Write a case study on Bhopal / Chernobyl / Fukushima (any one): causes, failures, impacts..
- b) List lessons learned and preventive strategies (engineering + management) to avoid recurrence and support “build back better”.



KNOWLEDGE IS POWER

| B24EC4L11 | COMMUNICA-<br>TION LAB | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|------------------------|---|---|---|---|--------|-------------------------|
|           |                        | 0 | 0 | 3 | 2 | 2      | 2024                    |

**Preamble**

This laboratory provides practical exposure to the analysis and implementation of analog and digital communication techniques, as well as the characterization of microwave devices and systems.

**Prerequisite**

B24EC3T03 : ANALOG AND DIGITAL COMMUNICATION

**Course Outcomes**

After the completion of the course the student will be able to

|             |                                                                                                                                                                                                            |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Implement pulse shaping, matched filtering, and eye-diagram analysis in digital communication systems, and assess Bit Error Rate (BER) performance for BPSK and QPSK modulations.[Apply]                   |
| <b>CO 2</b> | Evaluate numerical aperture, losses in optical fibers,the voltage-current (V-I) characteristics of laser diodes and LEDs to understand their operational behavior in optical communication setups. [Apply] |
| <b>CO 3</b> | Simulate and analyze microwave and antenna systems using antenna simulation software, including patch antenna design and radiation pattern measurement. [Apply]                                            |
| <b>CO 4</b> | Develop hands-on skills in communication system for the performance evaluation of RF, optical, and digital communication systems.[Apply]                                                                   |
| <b>CO 5</b> | Realise the characteristics of reflex klystrons, Gunn diodes, waveguides, and directional couplers through hands-on experimentation. [Apply]                                                               |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| <b>CO 1</b> | 3   | 3   | 2   | 3   | 3   |     |     |     | 1   |      |      |
| <b>CO 2</b> | 3   | 2   | 2   | 3   | 3   |     |     |     | 1   |      |      |
| <b>CO 3</b> | 3   | 3   | 3   | 3   | 3   |     |     |     |     | 1    |      |
| <b>CO 4</b> | 3   | 3   | 3   | 2   | 3   |     | 1   |     |     | 2    |      |
| <b>CO 5</b> | 3   | 3   | 2   | 2   | 3   |     |     |     |     | 2    |      |

## Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hour       |

## Continuous Internal Evaluation Pattern

|                       |          |
|-----------------------|----------|
| Attendance            | 10 marks |
| Continuous Assessment | 20 marks |
| Internal Test         | 20 marks |

## End semester Examination pattern

|                                |          |
|--------------------------------|----------|
| Preliminary Work               | 30 marks |
| Performance and Implementation | 20 marks |
| Result and Inference           | 30 marks |
| Viva                           | 20 marks |

## SYLLABUS

### LIST OF EXPERIMENTS

#### PART-A: Software Experiments (Any 3 are mandatory)

|   |                                                                                      |
|---|--------------------------------------------------------------------------------------|
| 1 | Pulse Shaping in Digital Communication.                                              |
| 2 | Matched filter and Eye-diagram.                                                      |
| 3 | Bit Error Rate (BER) Performance Evaluation of Binary Phase Shift Keying (BPSK).     |
| 4 | Bit Error Rate (BER) Performance Evaluation of Quadrature Phase Shift Keying (QPSK). |

#### PART-B: Optical Experiments (Any 3 are mandatory)

|   |                                                                    |
|---|--------------------------------------------------------------------|
| 1 | Measurement of Numerical Aperture of a fiber.                      |
| 2 | Study of losses in Optical fiber.                                  |
| 3 | Study of Voltage vs. Current (V-I) characteristics of Laser Diode. |
| 4 | Study of Voltage vs. Current (V-I) characteristics of LED.         |

#### PART-C: Microwave Experiments

|   |                                                                                                                                          |
|---|------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Familiarization with Antenna Simulation Software.                                                                                        |
| 2 | Design, Simulation, and Performance Analysis of a Rectangular Microstrip Patch Antenna Using Antenna Simulation Software.                |
| 3 | Experimental Measurement and Characterization of Antenna Radiation Patterns Using Microwave Test Bench and Pattern Recording Techniques. |

---

**PART-D: Antenna Experiments** (Any 3 are mandatory)

|   |                                                                                                                           |
|---|---------------------------------------------------------------------------------------------------------------------------|
| 1 | Reflex Klystron mode characteristics                                                                                      |
| 2 | GUNN diode characteristics.                                                                                               |
| 3 | Verify the relation between Guide wave length, free space wave length and cut off wave length for rectangular wave guide. |
| 4 | Directional Coupler Characteristics..                                                                                     |

**Reference Books**

1. Simon Haykin, Michael Moher, An Introduction to Analog and Digital Communications, 2nd Edition, Wiley India, 2007.
2. John G. Proakis, Masoud Salehi, Fundamentals of Communication Systems, Pearson Education, 2008.
3. Samuel L. Shanmugam, Microwave Devices and Circuits, 3rd Edition, Pearson Education, 2003.
4. M. L. Sisodia, Vijay Laxmi Gupta, Microwave Engineering, New Age International, 2005.
5. Taub and Schilling, Principles of Communication Systems, 4th Edition, Tata McGraw-Hill, 2017.
6. Gred Keiser Optical Fiber Communication 5/e Mc Graw Hill, 2013
7. Balanis, Antenna Theory and Design, 3/e, Wiley Publications.
8. Thomas A. Milligan, Modern Antenna Design, IEEE PRESS, 2/e, Wiley Inter science.
9. N.O. Sadiku and S.V. Kulkarni, Principles of Electromagnetics, Sixth Edition, Oxford University Press, India, 2015 (Asian adaptation of 'M.N.O. Sadiku, Elements of Electromagnetics, Sixth International Edition, Oxford University Press')



| B24EC4L12 | PROJECT<br>PHASE I | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|--------------------|---|---|---|---|--------|-------------------------|
|           |                    | 0 | 0 | 6 | 2 |        |                         |

**Preamble:**

The course 'Project Work' is mainly intended to evoke innovation and invention skills in students. It provides an opportunity to synthesize and apply knowledge and analytical skills to develop a prototype or simulation. Projects should be finalized in thrust areas of the engineering stream or as interdisciplinary efforts, with importance given to addressing societal problems, developing indigenous technologies, and aligning with sustainable development.

**Course Objectives**

- To apply engineering knowledge in practical problem-solving.
- To foster innovation in design of products, processes, or systems with consideration for sustainability.
- To develop creative thinking in finding viable, ethical, and socially relevant solutions to engineering problems.

**Course Outcomes:**

After the completion of the course the student will be able to

|             |                                                                                                                                                                                                                   |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Apply engineering knowledge across domains to model, analyze, and solve real-world problems through practical design, simulation, or prototyping. (Apply)                                                         |
| <b>CO 2</b> | : Develop innovative, sustainable, and socially relevant products, processes, or systems, addressing technology/research gaps while considering ethical, environmental, and SDG-aligned aspects. (Apply / Create) |
| <b>CO 3</b> | Function effectively as an individual and as a leader/member in diverse teams, demonstrating responsibility, collaboration, and task execution in multidisciplinary settings. (Apply)                             |
| <b>CO 4</b> | Plan, schedule, and execute project tasks efficiently using available resources, within timelines, while adhering to ethical, professional, and budgetary norms. (Apply)                                          |
| <b>CO 5</b> | Identify gaps through literature review and propose creative solutions; organize and communicate technical findings effectively in written reports and oral presentations. (Analyze / Apply)                      |

### Mapping of Course Outcomes With Program Outcomes (Latest Tier-1 NBA POs - 11 POs)

(Note: Correlation levels: 3 = High, 2 = Medium, 1 = Low, blank = None)

|      | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| CO 1 | 3   | 3   | 2   | 2   | 2   | 1   |     | 1   |     |      | 1    |
| CO 2 | 2   | 2   | 3   | 1   | 1   | 2   | 3   | 2   | 1   | 1    | 2    |
| CO 3 |     |     |     |     |     | 3   | 2   | 3   | 2   | 2    | 1    |
| CO 4 | 1   | 1   | 1   |     | 2   | 1   | 1   | 2   | 3   | 3    | 3    |
| CO 5 | 2   | 3   | 2   | 2   | 2   | 1   | 1   | 1   | 2   | 3    | 2    |

**SDG Relevance:** Projects should align with UN SDGs (e.g., SDG 9 for innovation/infrastructure, SDG 7/13 for clean energy/climate, SDG 11 for sustainable communities, SDG 3/6 for health/water, etc.), especially in CO2 and problem definition.

**Phase 1 Targets** (unchanged core, minor emphasis on sustainability/ethics):

- Literature study/survey.
- Formulation of objectives.
- Formulation of hypothesis/design/methodology.
- Work plan and task allocation.
- Block-level design documentation.
- Seeking project funds.
- Preliminary analysis/modeling/simulation/experiment/design/feasibility study/prototype.
- Preparation of Phase 1 report.

**Evaluation Guidelines & Rubrics Total: 100 marks** (Minimum to pass: 50)

|                                                  |           |
|--------------------------------------------------|-----------|
| Project progress evaluation by guide             | :30 marks |
| Interim evaluation by Evaluation Committee       | :30 marks |
| Final Evaluation by Evaluation Committee         | :30 marks |
| Project Phase-I Report (by Evaluation Committee) | :10 marks |

(The Evaluation Committee comprises HoD/Senior faculty, Project Coordinator, and Supervisor.)

**Evaluation by the Guide (30 Marks)**

| Sl. No. | Parameters                                                                                            | Marks | Poor (0-3/4-6)                                                                  | Fair                                                                   | Very Good (7-9)                                                               | Outstanding (10)                                                                                               |
|---------|-------------------------------------------------------------------------------------------------------|-------|---------------------------------------------------------------------------------|------------------------------------------------------------------------|-------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| 1-a     | Topic identification, selection, formulation of objectives and/or literature survey (Group) [CO1/CO5] | 15    | Failed to identify relevant topic timely; no literature; no objectives clarity. | Identified topic but lacks originality/-substance; limited references. | Good brainstorming; relevant topic; good literature; objectives mostly clear. | Highly relevant/innovative topic; excellent survey; clear, feasible objectives; strong societal/SDG relevance. |
| 1-b     | Project Planning, Scheduling, Resource/Tasks Identification & Allocation (Group) [CO4]                | 15    | No evidence of planning/scheduling/budget; poor task allocation.                | Some primary plan; incomplete schedules/journal.                       | Good planning; schedules prepared; better allocation.                         | Excellent planning; Gantt charts/modern tools; detailed budget; well-kept journal; clear individual tasks.     |

**Interim Evaluation (30 Marks - Group mostly)**

| Sl. No. | Parameters                                                                                            | Marks | Poor (0-3/4-6)                                                                  | Fair                                                                   | Very Good (7-9)                                                               | Outstanding (10)                                                                                               |
|---------|-------------------------------------------------------------------------------------------------------|-------|---------------------------------------------------------------------------------|------------------------------------------------------------------------|-------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| 1-a     | Topic identification, selection, formulation of objectives and/or literature survey (Group) [CO1/CO5] | 15    | Failed to identify relevant topic timely; no literature; no objectives clarity. | Identified topic but lacks originality/-substance; limited references. | Good brainstorming; relevant topic; good literature; objectives mostly clear. | Highly relevant/innovative topic; excellent survey; clear, feasible objectives; strong societal/SDG relevance. |
| 1-b     | Project Planning, Scheduling, Resource/Tasks Identification & Allocation (Group) [CO4]                | 15    | No evidence of planning/scheduling/budget; poor task allocation.                | Some primary plan; incomplete schedules/journal.                       | Good planning; schedules prepared; better allocation.                         | Excellent planning; Gantt charts/modern tools; detailed budget; well-kept journal; clear individual tasks.     |

**Final Evaluation (30 Marks - Mix of Group & Individual)**

| <b>Sl. No.</b> | <b>Parameters</b>                                                                         | <b>Marks</b> | <b>Poor</b>                                                | <b>Fair</b>                       | <b>Very Good</b>                           | <b>Outstanding</b>                                                                             |
|----------------|-------------------------------------------------------------------------------------------|--------------|------------------------------------------------------------|-----------------------------------|--------------------------------------------|------------------------------------------------------------------------------------------------|
| 1-c            | Formulation of Design/Methodology and Progress (Group) [CO1]                              | 5            | No evidence/-knowledge of design/methodology; no progress. | Some knowledge; limited progress. | Comfortable with methods; good progress.   | Clear/well-defined methodology; excellent adherence/progress.                                  |
| 1-d            | Individual & Teamwork Leadership (Individual) [CO3]                                       | 10           | Passive/no interest.                                       | Some interest (superficial).      | Good interest/responsibility/team support. | Leadership; clear evidence of leading/-supporting team.                                        |
| 1-e            | Preliminary Analysis/-Modeling/Simulation/Experiment/Design/Feasibility (Group) [CO1/CO2] | 10           | No preliminary work.                                       | Started but not thorough.         | Good evidence; can improve.                | Strong/excellent work; poised for strong completion; shows innovation/sustainability aspects.  |
| 1-f            | Documentation & Presentation (Group/Individual) [CO5]                                     | 5            | Poor/no documentation/presentation.                        | Some but incomplete.              | Good; needs improvement.                   | Professional (e.g., LaTeX); excellent structure/presentation; clear communication of findings. |

**Project Phase-I Report (10 marks)**

| Sl. No. | Parameters   | Marks | Poor (0-3)                                                  | Fair (4-6)                                                               | Very Good (7-8)                                                    | Outstanding (9-10)                                                                                                                             |
|---------|--------------|-------|-------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| 1-g     | Report [CO5] | 10    | Shallow; no standard format; poor organization & references | Follows format partially; some organization issues; few references cited | Good organization; standard format; most references cited properly | Exceptionally organized; professional format; all references/diagrams properly cited & presented; effective communication of technical content |

**General Guidelines**

- Team size: Preferably 4 members (Maximum 5 members) (Preferably from same batch unless for interdisciplinary projects).
- For the project, identify one base paper publication. It should be from IEEE, Elsevier, ACM journal, Science Citation Index (SCI) journal or a good Scopus Indexed journal. Conference papers are not permitted. Only recently published papers are allowed.
- For the literature survey at least 10 publications are to be reviewed.
- Try to get funding from agencies like KSCSTE, CERD, etc. Projects that can benefit society have more probability of attracting funding and prizes.
- Every student must keep their own project diary. It should be in the prescribed format. Record all details related to the project with dates. Every week, you must show the project diary to your project guide and get a signature (Or email approval if classes are handled in online mode). You will be asked to submit the project diaries periodically.
- At the end of the Seventh semester, a project report has to be prepared in the prescribed format.
- Proceed with project work, keeping in mind that preferably you need to publish one paper during the eighth semester.



| B24EC4L13 | SEMINAR | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|---------|---|---|---|---|--------|----------------------|
|           |         | 0 | 0 | 4 | 1 | 2      | 2024                 |

**Preamble:**

Seminar enables B.Tech graduates to search, read, comprehend, present, and report on academic/technical documents (e.g., peer-reviewed journals, conferences, books, theses, project reports). Students select a topic/paper in consultation with their guide, preferably linked to their final-year project area or emerging technologies with relevance to sustainable development. This fosters literature survey skills, presentation abilities, technical reporting, and awareness of broader societal/environmental impacts (aligned with SDGs like SDG 4: Quality Education, SDG 9: Industry/Innovation/Infrastructure, and SDG 13: Climate Action where applicable).

**Course Objectives**

- Conduct literature survey in a selected engineering area of interest.
- Understand and analyze academic/technical documents from peer-reviewed sources.
- Prepare and deliver an effective presentation on the selected document/topic.
- Prepare a comprehensive technical report with accurate references and consideration for sustainability/ethics where relevant.

**Course Outcomes:**

After the completion of the course the student will be able to

|             |                                                                                                                                                              |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Identify and select relevant academic documents from literature in their area of interest (Apply).                                                           |
| <b>CO 2</b> | Read, comprehend, and analyze an academic document/technical paper related to their area of interest (Analyze).                                              |
| <b>CO 3</b> | Prepare a structured presentation on the selected academic document (Create).                                                                                |
| <b>CO 4</b> | Deliver an effective presentation and engage in discussions/Q&A on the academic document (Apply).                                                            |
| <b>CO 5</b> | Prepare a well-structured technical report with proper references, formatting, and consideration for societal/sustainable aspects where applicable (Create). |



**Mapping of Course Outcomes With Program Outcomes** (Latest Tier-1 NBA POs - 11 POs)

|      | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| CO 1 | 2   | 2   | 1   | 1   | -   | 2   | 1   | -   | -   | -    | 3    |
| CO 2 | 3   | 3   | 2   | 3   | -   | 2   | 1   | -   | -   | -    | 3    |
| CO 3 | 3   | 2   | 2   | -   | 3   | -   | -   | 1   | -   | 2    | 3    |
| CO 4 | 3   | -   | -   | -   | 2   | -   | -   | 1   | -   | 3    | 3    |
| CO 5 | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | -   | 3    | 3    |

**General Guidelines**

- Department forms Internal Evaluation Committee (IEC): Academic coordinator (Chairperson), Seminar coordinator, and guide(s) as members. All IEC members present during presentations.
- IEC formation and guide allotment within one week after previous semester exams/end.
- Guide assists in topic/paper selection (current, broad-based; preferably linked to final-year project; consider SDG relevance where possible).
- Student selects topic/paper during semester break; finalize/submit to IEC in Week 1; IEC approves by Week 2.
- Accurate references from genuine peer-reviewed sources required (verified in report).
- Maintain seminar diary for weekly progress monitoring by guide.

**Evaluation Pattern**

**Total marks: 100** (CIE only, minimum required to pass: 50)

**1. Seminar Guide: 20 marks**

- **Background Knowledge (10 marks):** Assessed by the guide based on the student's depth of understanding demonstrated during weekly interactions, discussions, and diary entries.
- **Relevance of Topic/Paper Selected (10 marks):** Alignment with discipline, currency, breadth, linkage to final-year project/SDGs (if applicable), and justification.

**Rubric for Background Knowledge (10 marks)** Guide awards holistically or averages sub-criteria.

| Level          | Score | Descriptor                                                                                                                                 |
|----------------|-------|--------------------------------------------------------------------------------------------------------------------------------------------|
| Excellent      | 9–10  | Demonstrates exceptional grasp; explains concepts deeply, handles advanced questions confidently, shows critical insight beyond the paper. |
| Good           | 7–8   | Solid understanding; explains key ideas clearly, answers most questions accurately, shows good analysis.                                   |
| Satisfactory   | 5–6   | Basic understanding; explains main points but with gaps, answers simple questions, limited depth.                                          |
| Unsatisfactory | 0–4   | Poor/limited knowledge; struggles to explain basics, major misconceptions evident.                                                         |

**Rubric for Relevance of Topic/Paper (10 marks)**

| Level          | Score | Descriptor                                                                                                                           |
|----------------|-------|--------------------------------------------------------------------------------------------------------------------------------------|
| Excellent      | 9–10  | Highly relevant, current/emerging topic; strong linkage to discipline/project/SDG; broad yet focused; peer-reviewed sources premium. |
| Good           | 7–8   | Relevant and current; good project/SDG linkage; appropriate breadth.                                                                 |
| Satisfactory   | 5–6   | Moderately relevant; some linkage but narrow/specific or outdated.                                                                   |
| Unsatisfactory | 0–4   | Low relevance; no clear linkage, outdated, or non-peer-reviewed dominant.                                                            |

## 2. Seminar Coordinator: 20 marks

- **Seminar Diary (10 marks):** Weekly progress entries, guide approvals, regularity.
- **Attendance (10 marks)**

**Rubric for Seminar Diary (10 marks)**

| Level          | Score | Descriptor                                                                                                  |
|----------------|-------|-------------------------------------------------------------------------------------------------------------|
| Excellent      | 9–10  | Complete, detailed weekly entries; clear progress milestones; insightful reflections; all approvals timely. |
| Good           | 7–8   | Regular entries with good detail; most milestones tracked; approvals mostly on time.                        |
| Satisfactory   | 5–6   | Basic entries; some gaps in detail/progress; approvals irregular.                                           |
| Unsatisfactory | 0–4   | Incomplete/sparse entries; major gaps; few approvals.                                                       |

### 3. Presentation: 40 marks (Awarded by IEC – all members)

Analytic rubric applied during the presentation session.

| Criterion                                                                                             | Weight | Excellent (4)<br>– Full marks scaled                                                               | Good (3)                                                       | Satisfactory (2)                                                   | Unsatisfactory (1)                                                   |
|-------------------------------------------------------------------------------------------------------|--------|----------------------------------------------------------------------------------------------------|----------------------------------------------------------------|--------------------------------------------------------------------|----------------------------------------------------------------------|
| Clarity of Presentation (Structure, flow, delivery, time management)                                  | 10     | Exceptionally clear, logical flow, excellent delivery, perfect timing (within limits $\pm 10\%$ ). | Clear and well-structured, good delivery, minor timing issues. | Moderately clear, some disorganization, delivery fair, timing off. | Unclear, poor flow, mumbled delivery, major timing overrun/underrun. |
| Interactions / Q&A (Ability to answer questions, defend concepts, depth)                              | 10     | Confident, accurate, insightful answers; handles complex questions effectively.                    | Good answers to most questions; some depth shown.              | Basic answers; struggles with follow-ups.                          | Poor/inaccurate answers; unable to defend key points.                |
| Overall Participation (Involvement in peers' sessions – questions asked, feedback given)              | 10     | Highly active; insightful questions/feedback in most sessions.                                     | Active; contributes meaningfully in several sessions.          | Minimal participation; occasional questions.                       | Little/no involvement in others' sessions.                           |
| Quality of Slides (Visual appeal, content organization, technical accuracy, references, minimal text) | 10     | Outstanding design; error-free, well-organized, excellent visuals/references.                      | Good design; minor errors, clear organization.                 | Adequate but cluttered/average visuals.                            | Poor design; many errors, overcrowded, missing references.           |

**4. Report: 20 marks (Awarded by IEC)**

Analytic rubric for the final technical report.

| Criterion                                                                                                  | Weight | Excellent (4)<br>– Full marks scaled                                      | Good (3)                                           | Satisfactory (2)                            | Unsatisfactory (1)                                       |
|------------------------------------------------------------------------------------------------------------|--------|---------------------------------------------------------------------------|----------------------------------------------------|---------------------------------------------|----------------------------------------------------------|
| Technical Content & Depth (Analysis quality, relevance, originality, understanding of paper)               | 8      | In-depth critical analysis; original insights; excellent synthesis.       | Good analysis; clear understanding; some insights. | Basic summary; limited analysis.            | Superficial; major errors/-gaps.                         |
| Overall Quality & Structure (Formatting, language, grammar, templates followed, logical flow)              | 5      | Professional; flawless language/structure; adheres to template perfectly. | Good quality; minor errors; logical.               | Average; noticeable errors; fair structure. | Poor formatting; many errors; disorganized.              |
| Adequacy of References & Citations (Genuine peer-reviewed sources, proper style e.g. IEEE, in-text & list) | 4      | Extensive, high-quality sources; perfect citation style.                  | Adequate relevant sources; minor citation issues.  | Basic sources; some citation errors.        | Few/poor sources; major citation flaws/-plagiarism risk. |
| Consideration for Sustainability/Ethics/Societal Impact (SDG linkage, ethical aspects, where applicable)   | 3      | Strong, relevant discussion of impacts/SDGs/ethics.                       | Some discussion of broader impacts.                | Minimal mention.                            | No consideration.                                        |

| B24EC4T02 | VIVA VOCE | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|-----------|---|---|---|---|--------|----------------------|
|           |           | 0 | 0 | 0 | 0 | 1      | 2024                 |

### Preamble

100% Continuous Internal Evaluation (CIE) – No End Semester Examination (ESE). Minimum pass: 50 marks out of 100.

### Course Objectives

To evaluate the student's comprehensive understanding of core subjects studied up to 6th semester, ensuring retention, integration, and application of knowledge.

### Scope

Questions cover all core/program-specific courses from Semesters 1 to 6 (excluding open/minor electives unless specified). Includes basic to advanced concepts, problem-solving, derivations, applications, and interconnections between subjects.

### Conduct

Viva conducted by a panel (Internal examiner from the department, with HoD/senior faculty). Duration: 15–30 minutes per student (individual). May include follow-up questions, blackboard explanations, or simple derivations.

### Evaluation Scheme & Rubrics (Total: 100 Marks)

| Parameter                                                                                                                  | Marks | Poor (0–10)                                                                                                   | Fair (11–20)                                                                                          | Good (21–30)                                                                                             | Very Good (31–40)                                                                                                            | Excellent/Outstanding (41–50)                                                                                                                                                                        |
|----------------------------------------------------------------------------------------------------------------------------|-------|---------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Depth of Subject Knowledge (Core concepts, definitions, laws, theorems, derivations from all major core subjects up to S6) | 50    | Very limited recall; major gaps in fundamentals; unable to answer basic questions from >50% of core subjects. | Basic recall in some subjects; frequent prompting needed; gaps in key topics from multiple semesters. | Reasonable recall; answers most basic/medium questions correctly; minor gaps but can explain core ideas. | Strong grasp; handles medium-to-advanced questions well across most subjects; explains derivations/applications confidently. | Exceptional depth; accurate, quick recall; integrates concepts across subjects (e.g., links circuits to signals, math to engineering applications); handles advanced/challenging questions fluently. |



|                                                                                                                                                                                  |    |                                                                                                                                   |                                                                                                          |                                                                                                            |                                                                                                                                |                                                                                                                                                                          |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|-----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Under-<br>standing<br>& Ap-<br>plication<br>(Ability<br>to apply<br>concepts,<br>solve<br>simple<br>problems,<br>explain<br>real-world<br>relevance,<br>intercon-<br>nections)   | 20 | No mean-<br>ingful<br>applica-<br>tion; rote<br>answers<br>only; can-<br>not relate<br>concepts<br>or solve<br>basic<br>problems. | Limited<br>appli-<br>cation;<br>strug-<br>gles with<br>simple<br>problems<br>or real-<br>world<br>links. | Fair ap-<br>plication;<br>solves<br>basic<br>problems;<br>some<br>under-<br>standing<br>of rele-<br>vance. | Good ap-<br>plication;<br>solves<br>medium-<br>level prob-<br>lems; ex-<br>plains prac-<br>tical/in-<br>dustrial<br>relevance. | Outstanding<br>application;<br>solves unseen<br>problems cre-<br>atively; clearly<br>links concepts<br>across domains<br>and to soci-<br>etal/engineer-<br>ing contexts. |
| Clarity of<br>Expression<br>& Commu-<br>nication<br>(Verbal<br>clarity,<br>logical<br>flow, use of<br>technical<br>terms, con-<br>fidence in<br>answering)                       | 15 | Poor ar-<br>ticulation;<br>unclear/h-<br>esitant;<br>frequent<br>incom-<br>plete<br>answers<br>or mum-<br>bling.                  | Some-<br>what<br>clear but<br>disorga-<br>nized;<br>needs<br>repeti-<br>tion/promp-<br>ting often.       | Clear and<br>logical<br>most of<br>the time;<br>minor<br>hesita-<br>tions.                                 | Fluent,<br>well-<br>structured<br>answers;<br>confident<br>delivery;<br>uses precise<br>terminol-<br>ogy.                      | Highly articu-<br>late, confident,<br>and profes-<br>sional; excellent<br>logical flow;<br>engages panel<br>effectively.                                                 |
| Overall<br>Confi-<br>dence,<br>Attitude<br>& Respon-<br>siveness<br>(Body<br>language,<br>honesty in<br>admitting<br>unknowns,<br>eagerness<br>to learn/-<br>explain<br>further) | 15 | Ner-<br>vous/un-<br>respon-<br>sive;<br>defen-<br>sive or<br>silent on<br>difficult<br>questions.                                 | Some-<br>what<br>confi-<br>dent but<br>anxious;<br>partial re-<br>sponses.                               | Generally<br>confident;<br>admits<br>gaps rea-<br>sonably.                                                 | Confident<br>and com-<br>posed;<br>handles<br>pressure<br>well.                                                                | Highly confi-<br>dent, positive<br>attitude; turns<br>unknown ques-<br>tions into dis-<br>cussion points;<br>demonstrates<br>lifelong learning<br>mindset.               |

**Total: 100 Marks****Guidelines for Preparation & Conduct**

- Students should revise all core theory + lab courses from S1 to S6.



- Focus on fundamentals and advanced topics.
- Viva is usually scheduled in the last 1–2 weeks of the 7th semester.
- No written component; purely oral (may include diagrams/derivations on board).



| B24ECM7X | MINIPROJECT<br>(Minor) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|----------|------------------------|---|---|---|---|--------|-------------------------|
|          |                        | 3 | 1 | 0 | 5 | 4      | 2024                    |

### **Preamble:**

The Minor Project aims to

- Assess students' ability to transform theoretical knowledge into a functional working model.
- Enable experience in organizing and implementing small-scale projects.
- Facilitate design and development of a moderately complex project (hardware or hardware-software combination) with practical, sustainable applications.

### **Course Plan**

In groups of up to 4 students, design and develop a moderately complex system that addresses a real-world need or application (a functional working prototype/model is required). The project must meaningfully incorporate fundamental product design principles, including innovation, reliability, and aesthetics/ergonomics.

Students (in consultation with faculty/advisor):

- Identify topic of interest.
- Conduct literature review and gather information.
- State objectives and develop methodology.
- Perform design/fabrication/coding/programming.
- Demonstrate novelty/results/outputs (with SDG alignment where applicable).

Progress evaluated via minimum two reviews by committee (constituted by HoD). Submit project report at semester end. Demonstrate product against full specifications. Weightage given to innovative concepts, reliability, aesthetics/ergonomics, and societal/SDG relevance.

## Course Outcomes

After the completion of the course the student will be able to

|             |                                                                                                              |
|-------------|--------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Apply acquired knowledge in the selected technology area for project development and implementation. [Apply] |
| <b>CO 2</b> | Identify, discuss, and justify technical/design aspects of the project systematically. [Analyze]             |
| <b>CO 3</b> | Reproduce, improve, and refine technical aspects for engineering projects. [Apply]                           |
| <b>CO 4</b> | Collaborate effectively as a team in technical project development. [Apply]                                  |
| <b>CO 5</b> | Communicate and report project activities/findings effectively (written/oral). [Apply]                       |

## Mapping of Course Outcomes With Program Outcomes

|             | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> |
|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|
| <b>CO 1</b> | 3          | 3          | 3          | 2          | 2          | 3          | 1          | 1          | 1          | 1           | 2           |
| <b>CO 2</b> | 3          | 3          | 3          | 2          | 1          | 3          | 1          | 1          | 1          | 2           | 2           |
| <b>CO 3</b> | 3          | 3          | 3          | 2          | 2          | 3          | 1          | 1          | 1          | 1           | 2           |
| <b>CO 4</b> |            |            |            |            |            | 1          | 2          | 3          | 2          | 3           | 2           |
| <b>CO 5</b> |            |            |            |            | 1          | 1          | 1          | 2          | 3          | 2           | 2           |

**Evaluation Guidelines:** Total: 150 marks (CIE 75 + ESE 75). Minimum pass as per university norms.

### Split-up of CIE (75 marks)

|                                                                                                                   |           |
|-------------------------------------------------------------------------------------------------------------------|-----------|
| Attendance                                                                                                        | :10 marks |
| Marks awarded based on guide's evaluation                                                                         | :15 marks |
| Project Report                                                                                                    | :10 marks |
| Evaluation by Committee                                                                                           | :40 marks |
| (Committee: 3 members – HoD/senior faculty, Academic coordinator/program coordinator, project guide/coordinator.) |           |

### Split-up of ESE (75 Marks) (1-hour duration)

|                                               |           |
|-----------------------------------------------|-----------|
| Level of Completion                           | :10 marks |
| Demonstration of functionality/specifications | :25 marks |
| Project Report                                | :10 marks |
| Viva-voice                                    | :20 marks |
| Presentation                                  | :10 marks |

**Enhanced Rubrics for All Evaluation Components**

**1. Guide's Evaluation (CIE – 15 Marks)** Holistic assessment by guide (regular monitoring, involvement, progress).

| Parameter                                                        | Marks Allocation (out of 15) | Poor (0–3)                                           | Fair (4–7)                                   | Good (8–11)                                   | Very Good (12–14)                                           | Outstanding (15)                                                                  |
|------------------------------------------------------------------|------------------------------|------------------------------------------------------|----------------------------------------------|-----------------------------------------------|-------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Project Planning, Scheduling & Task Distribution [CO4/PO8, PO10] | 4                            | No plan/WBS; unbalanced/un-clear roles.              | Basic plan; skewed distribution.             | Reasonable plan/-timelines; mostly balanced.  | Detailed WBS/-timelines; equitable distribution documented. | Comprehensive planning; excellent equitable allocation; strong team coordination. |
| Technical Progress & Implementation [CO1, CO3 / PO1-PO5]         | 5                            | Minimal progress; major gaps in design/-fabrication. | Partial implementation; basic functionality. | Good progress; most objectives met partially. | Strong implementation; refined technical aspects.           | Excellent execution; innovative/refined design with SDG relevance.                |
| Individual & Team Involvement [CO4 / PO8]                        | 3                            | Low/no participation by some members.                | Uneven contribution.                         | Good involvement; fair equity.                | Consistent active participation.                            | Outstanding collaboration; leadership evident.                                    |
| Documentation & Regular Reviews [CO5 / PO9, PO11]                | 3                            | Poor/irregular records; no updates.                  | Basic records; inconsistent.                 | Good records; regular updates.                | Detailed logs/reviews.                                      | Exemplary documentation; reflective & timely.                                     |

## 2. Evaluation by Committee (CIE – 40 Marks)

Based on interim reviews (progress, demo, knowledge, involvement).

| Parameter                                              | Marks (out of 40) | Poor (0–10)                         | Fair (11–20)                      | Good (21–28)                             | Very Good (29–35)                                | Outstanding (36–40)                                         |
|--------------------------------------------------------|-------------------|-------------------------------------|-----------------------------------|------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|
| Technical Depth & Justification [CO1-CO3 / PO1-PO4]    | 15                | Superficial; no justification/gaps. | Basic explanation; limited depth. | Reasonable justification; some analysis. | Strong technical discussion/systematic approach. | Excellent depth; critical analysis; innovative/SDG-aligned. |
| Innovation & Practical Relevance [CO1, CO3 / PO3, PO6] | 10                | No novelty; routine.                | Limited innovation.               | Some novelty/practical aspects.          | Good innovation; practical/SDG relevance.        | Highly innovative; strong societal/SDG impact.              |
| Team Work & Involvement [CO4 / PO8]                    | 8                 | Poor collaboration.                 | Uneven involvement.               | Good team effort.                        | Strong collaboration.                            | Exemplary teamwork/leadership.                              |
| Communication & Presentation Readiness [CO5 / PO9]     | 7                 | Poor clarity.                       | Needs improvement.                | Adequate.                                | Clear & structured.                              | Professional & confident.                                   |

## 3. ESE Components – Enhanced Rubrics (75 Marks Total)

### • Level of Completion (10 Marks) [CO1–CO3]

- **Poor (0–2):** Incomplete; major unfinished parts.
- **Fair (3–5):** Partially complete; significant gaps.
- **Good (6–7):** Mostly complete; minor issues.
- **Very Good (8):** Fully complete with good quality.
- **Outstanding (9–10):** Exceptionally complete; exceeds expectations (innovative/SDG features).

### • Demonstration of Functionality/Specifications (25 Marks) [CO1, CO3 / PO3]

- **Poor (0–6):** Non-functional; fails specifications.
- **Fair (7–12):** Basic functionality; many failures.
- **Good (13–18):** Functional; meets most specifications with issues.
- **Very Good (19–22):** Reliable demonstration; meets all key specifications.
- **Outstanding (23–25):** Flawless; innovative features; reliable/SDG-aligned performance.
- **Project Report (10 Marks – CIE + ESE combined) [CO5 / PO9]**
  - **Poor (0–2):** Poor organization; incomplete or missing sections.
  - **Fair (3–5):** Basic format; weak language/references.
  - **Good (6–7):** Systematic; mostly consistent.
  - **Very Good (8):** Well-organized; good references.
  - **Outstanding (9–10):** Professional quality; excellent structure/readability; proper citations and SDG discussion.
- **Viva-voce (20 Marks) [CO2, CO5 / PO2, PO9]**
  - **Poor (0–5):** Unable to explain basics; lacks understanding.
  - **Fair (6–10):** Limited answers; frequent prompting.
  - **Good (11–14):** Answers most questions reasonably.
  - **Very Good (15–17):** Confident; good depth and explanation.
  - **Outstanding (18–20):** Excellent articulation; integrates concepts; handles challenges fluently.
- **Presentation (10 Marks) [CO5 / PO9]**
  - **Poor (0–2):** Poor delivery and structure.
  - **Fair (3–5):** Needs major improvement.
  - **Good (6–7):** Clear and logical.
  - **Very Good (8):** Professional flow.
  - **Outstanding (9–10):** Engaging and confident; excellent visuals and technical clarity.



| B24ECH71 | RF MEMS<br>(Honours) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|----------|----------------------|---|---|---|---|--------|-------------------------|
|          |                      | 3 | 1 | 0 | 5 |        |                         |

### Preamble

This course introduces the fundamentals of MEMS and their applications in RF and wireless systems, with emphasis on materials, micro fabrication techniques, RF MEMS components, micro machined antennas, and packaging technologies.

### Prerequisites

B24EC1T03 : SOLID STATE DEVICES

B24EC2T03 : VLSI CIRCUIT DESIGN

### Course Outcomes

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                                                             |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the concept of MEMS, various fabrication techniques and actuation mechanisms used in RF -MEMS design and apply them in practical situations. [Understand, Apply]                                 |
| <b>CO 2</b> | Analyze the structure, operation, modelling, fabrication, and packaging of RF MEMS switches, including capacitive shunt and series switches, and their performance for RF applications. [Understand, Apply] |
| <b>CO 3</b> | Design RF MEMS inductors and capacitors, by analyzing layout effects, stray capacitance reduction techniques, tunable mechanisms, and material choices. [Understand, Apply]                                 |
| <b>CO 4</b> | Explain the principles, design, and operation of RF MEMS filters and phase shifters. [Understand, Apply]                                                                                                    |
| <b>CO 5</b> | Design a basic MEMS-based antenna module by selecting suitable micromachining techniques and packaging methods. [Understand, Apply]                                                                         |

### Mapping of Course Outcomes With Program Outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| <b>CO 2</b> | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| <b>CO 3</b> | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| <b>CO 4</b> | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |
| <b>CO 5</b> | 3    | 3    | 3    | 3    | 2    | 1    |      |      |      |       | 3     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 30                    | 30                 | 30                                    |
| Apply            | 50                    | 50                 | 50                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## **SYLLABUS**

### **MODULE 1**

**Introduction to MEMS:** Intrinsic characteristics of MEMS - Sensors and Actuators - MEMS materials- Micro fabrication techniques- Surface micro machining, Bulk micro machining, LIGA - Review of electrical and mechanical concepts in MEMS-RF MEMS for wireless application, mechanical modelling of MEMS devices, Actuation mechanisms in MEMS: Piezoelectric, Electrostatic, Thermal, Magnetic.

### **MODULE 2**

**MEMS Switches:** Introduction to MEMS switches; Capacitive shunt and series switches: Physical description, circuit model and electromagnetic modelling; Techniques of MEMS switch fabrication and packaging; Design of MEMS switches.

### **MODULE 3**

**Inductors and Capacitors:** Micro machined passive elements; Micro machined inductors: Effect of inductor layout, reduction of stray capacitance of planar inductors, folded inductors, variable inductors and polymer-based inductors; MEMS Capacitors: Gap-tuning and area-tuning capacitors, dielectric tunable capacitors.

### **MODULE 4**

**RF Filters and Phase Shifters:** Principle of operation of micro machined filters, surface acoustic wave filters, micro machined filters for millimeter wave frequencies; Various types of MEMS phase shifters; Ferroelectric phase shifters, PIN diode phase shifters, Field effect transistor phase shifters.

### **MODULE 5**

**Micro machined antennas and MEMS packaging:** Micro machined antennas: Micro machining techniques to improve antenna performance, reconfigurable antennas. Integration and packaging: Role of MEMS packages, types of MEMS packages, module packaging, packaging materials and reliability issues.

### **Text Books**

1. Vijay Varadan, K. J. Vinoy, K. A. Jose, "RF MEMS and Their Applications", Wiley,

2003

2. Hector J. De Los Santos, "RF MEMS Circuit Design for Wireless Applications", Artech House, 2002
3. Gabriel M. Rebeiz, "RF MEMS: Theory, Design, and Technology", Wiley, 2003
4. Eun Sok kim "Fundamentals of Micro electro mechanical Systems (MEMS)" McGraw Hill
5. Tai-Ran Hsu, MEMS and Microsystems Design and Manufacture, TMH, 2002
6. Thomas B. Jones, Electromechanics and MEMS, Cambridge University Press, 2001



**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                             | <b>No of Lecture/Tutorial Hours</b> |
|-----------|----------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                          | <b>13</b>                           |
| 1.1       | MEMS-Introduction- Intrinsic characteristics of MEMS-MEMS materials.                                     | 2                                   |
| 1.2       | Sensors and Actuators.                                                                                   | 1                                   |
| 1.3       | Micro fabrication techniques- Surface micro machining, Bulk micro machining, LIGA process.               | 3                                   |
| 1.4       | Electrical and mechanical concepts in MEMS(concept only)- Mechanical modelling of MEMS devices.          | 2                                   |
| 1.5       | Actuation mechanisms in MEMS, piezoelectric, electrostatic, thermal, magnetic.                           | 3                                   |
| 1.6       | Electrical and mechanical concepts in MEMS(Concept only)- Mechanical modelling of MEMS devices.          | 2                                   |
|           | <b>Module 2</b>                                                                                          | <b>7</b>                            |
| 2.1       | MEMS switches : Introduction                                                                             | 1                                   |
| 2.2       | Capacitive shunt and series switches: Physical description,circuit model and electromagnetic modelling . | 3                                   |
| 2.3       | Techniques of MEMS switch fabrication and packaging                                                      | 1                                   |
| 2.4       | Design of MEMS switches                                                                                  | 2                                   |
|           | <b>Module 3</b>                                                                                          | <b>8</b>                            |
| 3.1       | Micromachined passive elements;Inductors and capacitors                                                  | 2                                   |
| 3.2       | Micromachined inductors: Effect of inductor layout reduction of stray capacitance of planar inductors    | 2                                   |
| 3.3       | folded inductors, variable inductors and polymer-based inductors                                         | 2                                   |
| 3.4       | MEMS Capacitors: Gap-tuning and area-tuning capacitors, dielectric tunable capacitors                    | 2                                   |
|           | <b>Module 4</b>                                                                                          | <b>8</b>                            |
| 4.1       | RF Filters and Phase Shifters:Principle of operation - micromachined filters                             | 2                                   |
| 4.2       | Surface acoustic wave filters                                                                            | 2                                   |
| 4.3       | Micromachined filters for millimeter wave frequencies                                                    | 2                                   |
| 4.4       | Various types of MEMS phase shifters; Ferroelectric phase shifters                                       | 2                                   |
|           | <b>Module 5</b>                                                                                          | <b>8</b>                            |
| 5.1       | Micromachined antennas: Micromachining techniques to improve antenna performance                         | 2                                   |
| 5.2       | Reconfigurable antennas                                                                                  | 2                                   |
| 5.3       | Integration and Packaging: Role of MEMS packages, types of MEMS packages                                 | 2                                   |

|     |                                                              |                 |
|-----|--------------------------------------------------------------|-----------------|
| 5.4 | Module packaging, packaging materials and reliability issues | 2               |
|     | <b>Total Hours</b>                                           | <b>44 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the intrinsic characteristics of MEMS and discuss how these characteristics influence the selection of sensors and actuators in MEMS-based systems.
2. Compare surface micromachining, bulk micromachining, and LIGA processes with respect to fabrication steps, achievable structures, and suitability for RF MEMS applications. Justify your comparison.

#### Course Outcome 2 (CO 2):

1. Describe the working principle of capacitive shunt and series MEMS switches. Develop the equivalent circuit model for each and explain their switching behavior.
2. Analyze the design challenges in MEMS switch fabrication and packaging. Evaluate how packaging techniques impact RF performance, reliability, and switching speed.

#### Course Outcome 3 (CO 3):

1. Discuss the effect of inductor layout on performance parameters such as Q-factor and self-resonant frequency. Explain how folded inductors and polymer-based inductors reduce parasitic effects.
2. Illustrate and explain the operation of gap-tuning and area-tuning MEMS capacitors with their application in RF tuning circuits.

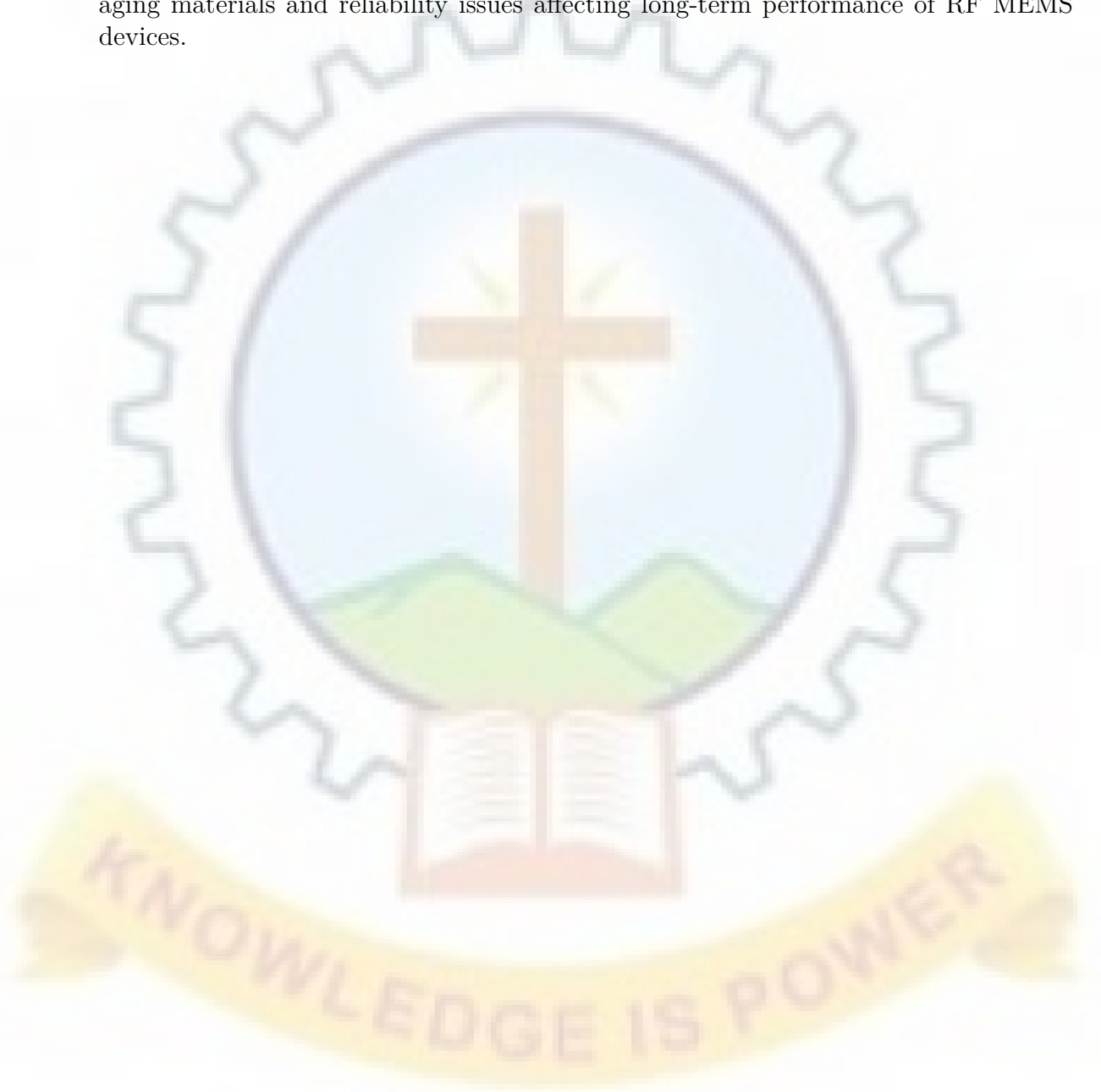
#### Course Outcome 4 (CO 4):

1. Explain the principle of operation of micro machined RF filters and surface acoustic wave (SAW) filters. Highlight their suitability for millimeter-wave frequency applications.
2. Evaluate the suitability of MEMS-based phase shifters over conventional semiconductor phase shifters for phased array applications. Support your answer by comparing loss, linearity, power handling, and tuning range.



**Course Outcome 5 (CO 5):**

1. Explain how micro machining techniques are employed to enhance antenna performance parameters such as gain, bandwidth, efficiency, and radiation characteristics. Illustrate your answer with reference to reconfigurable MEMS antennas.
2. Discuss the role of MEMS packaging in system integration. Evaluate different packaging materials and reliability issues affecting long-term performance of RF MEMS devices.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027**

**Course Code: B24ECH71**

**Course Name: RF MEMS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. List three applications of MEMS technology in RF communication devices.
2. Explain why electrostatic actuation is preferred over magnetic actuation in MEMS devices.
3. List the advantages of cantilever switches used in RF MEMS.
4. Mention the differences between series and shunt RF MEMS switches.
5. Explain any one key parameter used in the design of MEMS inductors.
6. Which of the two MEMS capacitors—area-tuning or gap-tuning—is preferred? Justify your answer.
7. Explain the significance of Q-factor in the design of MEMS filters.
8. Explain one practical application of phase shifters in RF systems.
9. What are the parameters to be optimized in the design of microstrip antennas?
10. State three reliability issues in RF Microsystems packaging

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Describe the MEMS materials used in microfabrication. Explain their mechanical, electrical, and thermal properties relevant to MEMS applications. (7)  
b) Describe various actuation mechanisms in MEMS. Explain the working principles of piezoelectric and magnetic actuators. (7)
12. a) Explain the role of RF MEMS in wireless applications. Discuss their advantages over conventional RF components. (7)  
b) Explain in detail the surface micromachining process with neat sketches. Highlight its advantages and limitations. (7)

**Module II**

13. a) Discuss the design, fabrication, and packaging of RF MEMS switches. Explain the fabrication techniques, packaging approaches, and analyze the challenges related to reliability, stiction, and power handling. (14)
14. a) With suitable diagrams, explain the electromagnetic modelling of MEMS switches. Discuss how modelling influences insertion loss, isolation, and switching speed. (14)

**Module III**

15. a) Explain the concept of variable MEMS inductors. Discuss their operating principle, tuning methods, and applications in reconfigurable RF circuits. (8)  
b) Explain micromachined capacitors in detail. (6)
16. a) With neat sketches describe the fabrication process of any micro machined inductor. (7)  
b) With the help of relevant equations show how inductance is varied in micro machined inductors. (7)

**Module IV**

17. a) Explain micro machined filters for millimeter wave frequencies. (7)  
b) Describe the advantages and applications of phase shifters. (7)
18. a) Explain in detail the working and construction of a ferroelectric phase shifter. (8)  
b) Describe the advantages and applications of phase shifters. (6)

**Module V**

19. Discuss the role of MEMS packaging in system integration. Explain the types of MEMS packages, module-level packaging approaches, and packaging materials. (14)
20. Describe different reconfigurable antenna architectures using MEMS technology. Evaluate their advantages in modern wireless communication systems. (14)

| <b>B24ECH72</b> | <b>DESIGN AND ANALYSIS OF ANTENNAS (Honours)</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF INTRODUCTION</b> |
|-----------------|--------------------------------------------------|----------|----------|----------|----------|---------------|-----------------------------|
|                 |                                                  | 3        | 1        | 0        | 5        |               |                             |

**Preamble**

This course aims to impart knowledge on the basic parameters, matching techniques, design and working of various broad band antennas, practical antennas, antenna arrays and its radiation patterns. It also introduces standard software to design antennas with a set of given specifications.

**Prerequisites**

B24EC3T06: Electromagnetic Theory

B24EC4P42: Microwave and Antennas

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                    |
|-------------|----------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the concept of radiation mechanism, antenna parameters and antenna matching techniques. |
| <b>CO 2</b> | Illustrate the far field pattern of different types of antennas.                                   |
| <b>CO 3</b> | Analyze different types of broad band antennas and its radiation patterns.                         |
| <b>CO 4</b> | Design of various practical antennas, antenna arrays and field patterns.                           |
| <b>CO 5</b> | Familiarize Antenna Design Software and design microstrip patch antenna.                           |

**Mapping of Course Outcomes With Program Outcomes**

|             | <b>PO 1</b> | <b>PO 2</b> | <b>PO 3</b> | <b>PO 4</b> | <b>PO 5</b> | <b>PO 6</b> | <b>PO 7</b> | <b>PO 8</b> | <b>PO 9</b> | <b>PO 10</b> | <b>PO 11</b> |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|
| <b>CO 1</b> | 3           | 3           | 2           | 1           | 2           |             |             |             |             |              | 2            |
| <b>CO 2</b> | 3           | 3           | 2           | 2           | 1           |             |             |             |             |              | 2            |
| <b>CO 3</b> | 3           | 3           | 3           | 2           | 2           |             |             |             |             |              | 2            |
| <b>CO 4</b> | 3           | 3           | 3           | 3           | 2           |             |             |             |             |              | 3            |
| <b>CO 5</b> | 3           | 2           | 3           | 2           | 3           |             |             |             |             |              | 3            |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 20                    | 20                 | 20                                    |
| Understand       | 30                    | 30                 | 30                                    |
| Apply            | 50                    | 50                 | 50                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## **SYLLABUS**

### **MODULE 1**

Review of Antenna Parameters: Polarization, Input impedance, Gain. Relation between radiation fields and magnetic vector potential – Helmholtz equation and Lorentz conditions. Antenna matching – T match, Baluns, Gamma and Omegamatch. Review of dipole antennas (short dipole and arbitrary length), Monopole antennas, and rhombic antennas. Folded dipole and its properties.

### **MODULE 2**

Analysis of Circular Loop and Biconical Antenna. Helical Antennas (normal mode and axial mode) – relation for far fields, radiation resistance and gain. Current induced in a dipole antenna – Pocklington and Hallen's integral equations. Solution of Hallen's integral equation for current induced in a dipole antenna for delta gap model.

### **MODULE 3**

Near fields of linear antennas, self and mutual impedance, arrays of parallel dipoles, Yagi-Uda antennas. Aperture antenna – Field equivalence principle. Radiation from open-ended wave-guides, horn antennas, horn radiation fields, horn directivity, optimum horn design, Rectangular micro-strip antennas – field analysis and design. Designing an antenna with a set of given specifications using standard software (MATLAB/HFSS/CST Microwave Studio or any Open software)

### **MODULE 4**

Parabolic reflector antennas, gain and beam width of reflector antennas, aperture-field and current distribution methods, radiation patterns of reflector antennas, dual reflector antennas, lens antennas -hyperbolic lens and zoned lens. Frequency independent antennas – Rumsey Principle – Spiral Antennas. Design of log periodic dipole arrays.

### **MODULE 5**

Antenna arrays – General expression for array factor. Grating lobes. One dimensional arrays- Broad side, end fire and Chebyshev arrays. Concept of beam steering. Design of array using Schelkunoff's zero placement method and Fourier series method. Woodward-Lawson frequency-sampling design, Narrow beam design and Butler matrix beam former. Adaptive Beam forming. 2D arrays – Rectangular and Circular array.



**Text Books**

1. Sopholes J. Orfanidis – Electromagnetic waves and antennas. Available at: <http://eceweb1.rutgers.edu/orfanidi/ewa/>
2. Consrantive A Balanis -Antenna Theory - Analysis and Design – 2/e John Wiley & Sons.
3. John D. Krans, Ronald J. Marhefka : Antennas for all Applications , 3/e, TMH
4. Thomas A Milligan – Modern Antenna Design, 2/e John Wiley & Sons.



**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                                                                                                                               | No of Lecture/Tutorial Hours |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                                     | <b>9</b>                     |
| 1.1 | Basic antenna parameters (all parameters and related simple problems), Relation between parameters (derivation required)                                            | 1                            |
| 1.2 | Relation between radiation fields and magnetic vector potential – Helmholtz equation and Lorentz conditions.                                                        | 2                            |
| 1.3 | Antenna matching –T match, Baluns, Gamma and Omega match                                                                                                            | 2                            |
| 1.4 | Review of dipole antennas (short dipole and arbitrary length),                                                                                                      | 2                            |
| 1.5 | Monopole antennas, V and rhombic antennas. Folded dipole and its properties.                                                                                        | 2                            |
|     | <b>Module 2</b>                                                                                                                                                     | <b>9</b>                     |
| 2.1 | Analysis of Circular Loop and Biconical Antenna.                                                                                                                    | 2                            |
| 2.2 | Helical Antennas (normal mode and axial mode) – relation for far fields, radiation resistance and gain.                                                             | 2                            |
| 2.3 | Current induced in a dipole antenna – Pocklington and Hallen's integral equations.                                                                                  | 3                            |
| 2.4 | Solution of Hallen's integral equation for current induced in a dipole antenna for delta gap model.                                                                 | 2                            |
|     | <b>Module 3</b>                                                                                                                                                     | <b>10</b>                    |
| 3.1 | Near fields of linear antennas, self and mutual impedance, arrays of parallel dipoles, Yagi-Uda antennas.                                                           | 2                            |
| 3.2 | Aperture antenna – Field equivalence principle.                                                                                                                     | 2                            |
| 3.3 | Radiation from open-ended wave-guides, horn antennas, horn radiation fields, horn directivity, optimum horn design,                                                 | 2                            |
| 3.4 | Rectangular micro-strip antennas – Field analysis and design.                                                                                                       | 2                            |
| 3.5 | Designing an antenna with a set of given specifications using standard software(MATLAB/HFSS/CST Microwave Studio or any Open software).                             | 2                            |
|     | <b>Module 4</b>                                                                                                                                                     | <b>8</b>                     |
| 4.1 | Parabolic reflector antennas, gain and beam width of reflector antennas, aperture field and current distribution methods, radiation patterns of reflector antennas, | 2                            |
| 4.2 | Dual-reflector antennas, lens antennas -hyperbolic lens and zoned lens.                                                                                             | 2                            |
| 4.3 | Frequency independent antennas – Rumsey Principle – Spiral Antennas.                                                                                                | 2                            |

|     |                                                                                              |                 |
|-----|----------------------------------------------------------------------------------------------|-----------------|
| 4.4 | Design of log periodic dipole arrays.                                                        | 2               |
|     | <b>Module 5</b>                                                                              | <b>9</b>        |
| 5.1 | Antenna arrays – General expression for array factor. Grating lobes.                         | 1               |
| 5.2 | One dimensional arrays- Broad side, end fire and Chebyshev arrays. Concept of beam steering. | 2               |
| 5.3 | Design of array using Schelkunoff's zero placement method and Fourier series method.         | 2               |
| 5.4 | Woodward-Lawson frequency-sampling design, Narrow beam design and Butler matrix beam former. | 2               |
| 5.5 | Adaptive Beam forming. 2D arrays – Rectangular and Circular array.                           | 2               |
|     | <b>Total Hours</b>                                                                           | <b>45 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the steps involved in the design of a T-match circuit
2. With the help of neat sketches explain the working of a Rhombic Antenna and its features.

#### Course Outcome 2 (CO 2):

1. Derive the expressions for the fields radiated by a circular loop antenna.
2. Explain solution of Hallen's Integral equation using delta gap model.

#### Course Outcome 3 (CO 3):

1. Design an aperture antenna, with uniform illumination, so that the directivity is maximized at an angle of 300 degrees from the normal to the aperture. Determine the optimum dimension and its associated directivity when the aperture is (i) square, (ii) circular.
2. Design a Microstrip patch antenna for 2.4 GHz. The patch substrate has a dielectric of 2.2 and with height 2.2 mm.

#### Course Outcome 4 (CO 4):

1. Explain the working of Lens Antenna. What do mean by zoning in Lens Antenna?
2. Design a broad side Dolph-Tschebycheff array of 10 elements with spacing  $d$  between the elements and with a major to minor lobe ratio of 26 dB. Find the excitation coefficients and form the array factor.

**Course Outcome 5 (CO 5):**

1. Design a rectangular patch antenna operates at 5.5GHz. Use FR4/Duroid RT5870 as the substrate of patch antenna. Determine the thickness from data sheet. Write a procedure in order to design desired antenna by giving all equations, dimensions and simulation results (using MATLAB/HFSS/CST Microwave Studio or any Open software)
2. By using the rectangular patch antenna which is designed in Question no 1 as unit element, designing 1x4 array antennas at 5.5GHz on FR4/Duroid RT 5870 substrate. Determine the optimum distance between the unit element using HFSS and also give simulation results (radiation pattern, VSWR plot etc.).

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24ECH72**

**Course Name: DESIGN AND ANALYSIS OF ANTENNAS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Using Lorentz condition show that  $\nabla^2 \mathbf{A} + k^2 \mathbf{A} = -\mu \mathbf{J}$ .
2. Explain design procedure of Gamma match.
3. Derive expression for input impedance of a folded dipole antenna.
4. Derive radiated fields for a circular loop of constant current.
5. Explain the delta gap model in dipole antennas.
6. Derive the expression for far field pattern of an open ended wave guide.
7. Discuss about the Frequency Sampling Technique for Array Design.
8. Explain the working of Spiral Antenna. Derive appropriate expressions.
9. Design an Antenna Array using Schelkunoff's Zero Placement technique.
10. Explain Butler Matrix Beam Forming.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Derive the relation between the magnetic vector potential and radiation fields in antennas, stating clearly the Helmholtz equation and Lorentz conditions. (9)  
b) An antenna has an overall length  $l = 5\lambda$ . Observations are made at a distance  $r = 60\lambda$ . Find the errors in phase and amplitude using the far-field approximation. (5)
12. a) Derive expressions for the Far Field components and Radiation Resistance and Directivity of a short dipole antenna. (6)  
b) Derive the self and mutual impedance of two parallel Centers driven coupled dipole antennas. (8)

**Module II**

13. a) Design an axial mode helical antenna for directivity 28 dBi for operating at 600 MHz. Calculate the radiation resistance, HPBW, BWFN and bandwidth of the designed antenna. (5)  
b) Derive Pocklington's and Hallen's Integral Equation. Explain their significance. (9)
14. a) Explain the Field Equivalence Principle in detail. (5)  
b) Derive the expressions for power density, radiation resistance, and directivity of Circular loop antenna. (9)

**Module III**

15. a) Design a rectangular Microstrip antenna resonating at 2 GHz. The antenna uses a substrate with a dielectric of 10.2 and the height of the substrate is 0.3 cm. (8)  
b) Derive expressions for the Directivity of a Horn Antenna. (6)
16. a) Design a Yagi-Uda array with a directivity of 9.2 dB at a frequency  $f = 50$  MHz. The desired diameter of the parasitic elements is 2.54 cm and the diameter of the metal supporting boom is 5.1 cm. Find the element spacing, element lengths, and the total array length. (7)  
b) State Huygens' Principle and discuss field equivalence in aperture antennas. (7)

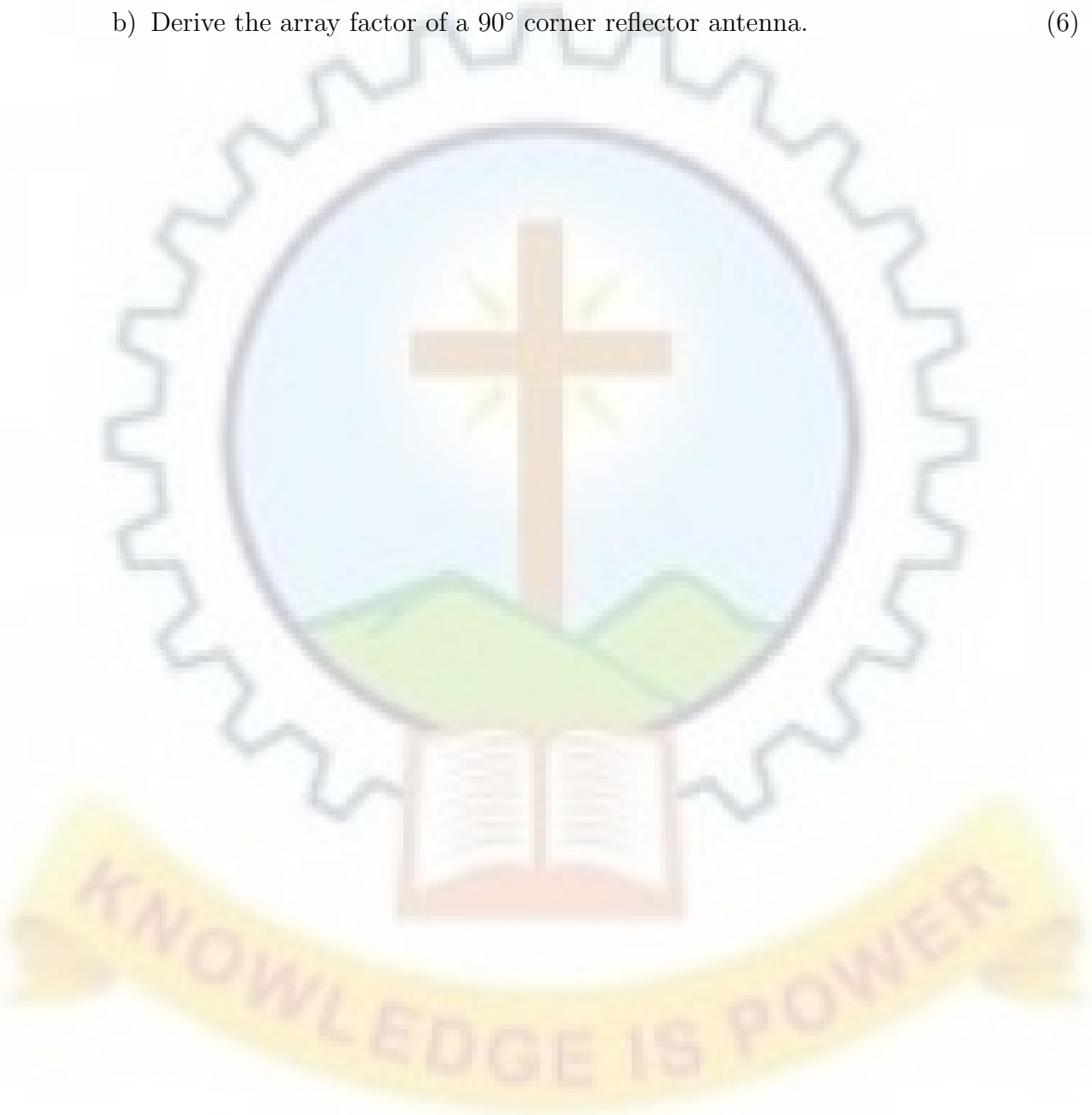
**Module IV**

17. a) Design a LPDA with  $\tau = 0.85$  and  $\sigma = 0.03$  for the frequency range 15 MHz – 45 MHz. (7)  
b) Explain the working of a parabolic dish antenna. Write down the expression for gain, HPBW and BWFN. (7)
18. a) Derive Rumsey Principle for frequency independent antennas. (7)  
b) Why equiangular spiral antenna and log periodic antennas are called frequency independent antennas. Explain their working. (7)



**Module V**

19. a) Design an antenna array using Schelkunoff's zero placement method. (7)  
b) Design a 5 element Dolph-Tschebycheff array with peak side lobe level 22 dB. (7)
20. a) Design an antenna array using Woodward-Lawson Frequency Sampling technique. (8)  
b) Derive the array factor of a  $90^\circ$  corner reflector antenna. (6)



| B24ECH73 | MULTIRATE<br>SIGNAL<br>PROCESSING AND<br>WAVELETS<br>(Honours) | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|----------|----------------------------------------------------------------|---|---|---|---|--------|-------------------------|
|          |                                                                | 3 | 1 | 0 | 5 | 4      | 2024                    |

### Preamble

The aim of this course is to introduce the idea of wavelets, and the related notions of time frequency analysis, of time-scale analysis, and to describe the manner in which technical developments related to wavelets have led to numerous applications. The concepts of multirate filter banks is also introduced. The relation between wavelets and multirate systems is brought out to illustrate how wavelets may actually be realized in practice.

**Prerequisites:** B24EC3T01 DIGITAL SIGNAL PROCESSING

### Course Outcomes

After the completion of the course, the student will be able to:

|             |                                                                                                                                              |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the fundamentals of multirate signal processing and filter banks used in signal decomposition and reconstruction. [Understand]    |
| <b>CO 2</b> | Understand the principles of wavelet transform and its role in time-frequency signal analysis. [Understand]                                  |
| <b>CO 3</b> | Analyse multiresolution analysis (MRA) and the relationship between wavelets and filter bank structures.[Analyse]                            |
| <b>CO 4</b> | Analyse and apply biorthogonal wavelets for signal representation and reconstruction. [Analyse]                                              |
| <b>CO 5</b> | Apply wavelet packet transform and two-dimensional discrete wavelet transform (2-D DWT) for advanced signal processing applications. [Apply] |

### Mapping of Course Outcomes With Program Outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 3    | 3    | 3    |      |      |      |      |      |       |       |
| <b>CO 2</b> | 3    | 3    |      |      |      |      |      |      |      |       |       |
| <b>CO 3</b> | 3    | 3    |      | 2    |      |      |      |      |      |       |       |
| <b>CO 4</b> | 3    | 3    | 2    |      |      |      |      |      |      |       |       |
| <b>CO 5</b> | 3    | 3    | 2    | 2    | 3    |      |      |      |      |       |       |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 10                    | 10                 | 10                                    |
| Understand       | 20                    | 20                 | 40                                    |
| Apply            | 20                    | 20                 | 50                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Basics of Multirate processing and Filter banks:** Introduction to multiresolution and multirate signal processing with some example applications, Multirate System Fundamentals: Basic multirate operations – Decimation and Interpolation, Transform domain analysis of Decimators and Interpolators, Decimation and Interpolation filters, Fractional sampling rate alteration Interconnection of decimators and interpolators, The Noble Identities.

**Introduction to digital filter banks:** The DFT filter bank, Two Channel Quadrature Mirror Filterbank (QMF), Two channel Conjugate Quadrature Filter Bank (CQF). Perfect Reconstruction.

### MODULE 2

**Introduction to Wavelet Transform:** The Uncertainty Principle - Time-bandwidth product uncertainty, The time frequency plane and its tilings, Short Time Fourier Transform, The Gabor Transform and its generalization, Wavelet Transform in general and origin of Wavelets. The Continuous Wavelet Transform (CWT), Condition of admissibility and its implications.

**Introduction to Discrete Wavelet Transform (DWT),** DWT from CWT, Logarithmic Scale Discretization and Dyadic Discretization, Families of wavelets: Orthogonal and biorthogonal wavelets, Vanishing moments and regularity.

### MODULE 3

**The Multiresolution Analysis (MRA), Wavelets and Filter Banks:** The Multiresolution Analysis: The Dyadic Haar Multiresolution Analysis - The Haar Scaling Functions and Function spaces, Nested spaces, The Haar Wavelet function, Orthogonality of the Haar Scaling and Wavelet functions. Relating Scaling and Wavelet functions of Haar and Filters, The Haar Filter Bank, Z-domain analysis of Haar filter bank.

The Daubechies' family of MRA, Daubechies' Filter banks, Relating QCF filter banks and Daubechies' wavelets.

### MODULE 4

**Biorthogonal Wavelets:** Introduction to biorthogonal vector space, Biorthogonal Wavelet Systems, Signal representation using Biorthogonal Wavelet System, Construction of Biorthogonal wavelets Design of Wavelet systems using frequency domain approach – Frequency domain characterisation of filter coefficients, Design of Daubechies Wavelets using frequency domain approach, JPEG 2000 5/3 filter bank and Spline MRA.

### MODULE 5

**Wavelet packets and 2-D DWT:** The wavelet packet transform, Best wavelet packet tree, Noble identities and the Haar wave Packet Transform. Introduction to 2-D DWT, Wavelet transform of an image, The Embedded Zero-tree Wavelet (EZW) Coding. Applications of wavelets in audio & image compression and denoising.

### **Text Books**

1. P. P. Vaidyanathan, Multirate Systems and Filter Banks, Pearson Education, 2006.
2. K. P. Soman, K. I. Ramachandran, "Insight Into Wavelets - From Theory to Practice", Prentice Hall of India, 3rd Edition, Eastern Economy Edition, Prentice Hall of India Private Limited, 2010.

### **Reference Books**

1. Gilbert Strang and Truong Q. Nguyen, Wavelets and Filter banks, 2nd Edition, Wellesley-Cambridge Press, 1998.
2. Raghuvver M. Rao, Ajit S. Bopardikar, "Wavelet Transforms: Introduction to Theory and Applications, Prentice Hall, 1998.
3. N.J. Fliege, Multirate Digital Signal Processing, John Wiley, 1999.
4. Video lectures and Transcripts: Adv. Digital Signal Processing: Multirate and Wavelet NPTEL Lecture series -<https://nptel.ac.in/courses/117/101/117101001/>

## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                                                                                       | No of Lecture/Tutorial Hours |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                                                                                             | <b>10</b>                    |
| 1.1 | Introduction to multiresolution and multirate signal processing with some example applications.                                                                                                                             | 1                            |
| 1.2 | Multirate System Fundamentals: Basic multirate operations – Decimation and Interpolation, Transform domain analysis of Decimators and Interpolators, Decimation and Interpolation filters.                                  | 2                            |
| 1.3 | Fractional sampling rate alteration                                                                                                                                                                                         | 1                            |
| 1.4 | Interconnection of decimators and interpolators, The Noble Identities.                                                                                                                                                      | 1                            |
| 1.5 | Introduction to digital filter banks, The DFT filter bank.                                                                                                                                                                  | 2                            |
| 1.6 | Two Channel Quadrature Mirror Filterbank (QMF)                                                                                                                                                                              | 1                            |
| 1.7 | Two Channel Conjugate Quadrature Filter Bank (CQF). Perfect Reconstruction.                                                                                                                                                 | 2                            |
|     | <b>Module 2</b>                                                                                                                                                                                                             | <b>10</b>                    |
| 2.1 | The Uncertainty Principle - Time-bandwidth product uncertainty, The time frequency plane and its tilings.                                                                                                                   | 2                            |
| 2.2 | Short time Fourier Transform, The Gabor Transform and its generalization, Wavelet Transform in general and origin of Wavelets.                                                                                              | 2                            |
| 2.3 | The Continuous Wavelet Transform (CWT), Condition of admissibility and its implications.                                                                                                                                    | 2                            |
| 2.4 | Introduction to Discrete Wavelet Transform (DWT), DWT from CWT, Logarithmic Scale Discretization and Dyadic Discretization                                                                                                  | 2                            |
| 2.5 | Families of wavelets: Orthogonal and biorthogonal wavelets, Vanishing moments and regularity.                                                                                                                               | 2                            |
|     | <b>Module 3</b>                                                                                                                                                                                                             | <b>9</b>                     |
| 3.1 | The Multiresolution Analysis: The Dyadic Haar Multiresolution Analysis - The Haar Scaling Functions and Function spaces, Nested spaces, The Haar Wavelet function, Orthogonality of the Haar Scaling and Wavelet functions. | 3                            |
| 3.2 | Relating Scaling and Wavelet functions of Haar and Filters, The Haar Filter Bank, Z-domain analysis of Haar filter bank.                                                                                                    | 3                            |
| 3.3 | The Daubechies' family of MRA, Daubechies' Filter banks, Relating QCF filter banks and Daubechies' wavelets.                                                                                                                | 3                            |
|     | <b>Module 4</b>                                                                                                                                                                                                             | <b>8</b>                     |
| 4.1 | Introduction to biorthogonal vector space, Biorthogonal Wavelet Systems.                                                                                                                                                    | 2                            |



|     |                                                                                                                                                                                      |                 |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 4.2 | Signal representation using Biorthogonal Wavelet System, Construction of Biorthogonal wavelets                                                                                       | 2               |
| 4.3 | Design of Wavelet systems using frequency domain approach – Frequency domain characterisation of filter coefficients, Design of Daubechies Wavelets using frequency domain approach. | 3               |
| 4.4 | JPEG 2000 5/3 filter bank and Spline MRA.                                                                                                                                            | 1               |
|     | <b>Module 5</b>                                                                                                                                                                      | <b>9</b>        |
| 5.1 | The wavelet packet transform, Best Wavelet packet tree, Noble identities and the Haar wave Packet Transform.                                                                         | 3               |
| 5.2 | Introduction to 2-D DWT, Wavelet transform of an image                                                                                                                               | 3               |
| 5.3 | The Embedded Zero-tree Wavelet (EZW) Coding.                                                                                                                                         | 1               |
| 5.4 | Applications of wavelets in audio & image compression and denoising                                                                                                                  | 2               |
|     | <b>Total Hours</b>                                                                                                                                                                   | <b>45 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the basic building blocks of a multirate/ multi resolution analysis system. Analyse the frequency domain behavior of the rate conversion operations to build analysis and synthesis filters of a filter bank.
2. State and prove the Noble Identities for both decimation and interpolation. Using a block diagram, demonstrate how these identities are used to simplify a multirate system.

#### Course Outcome 2 (CO 2):

1. Discuss the Heisenberg Uncertainty Principle in the context of signal processing. Compare the time-frequency tilings of the Short-Time Fourier Transform (STFT) and the Wavelet Transform using neat diagrams.
2. Explain how the Discrete Wavelet Transform (DWT) is derived from the CWT. Differentiate between Logarithmic Scale Discretization and Dyadic Discretization.

#### Course Outcome 3 (CO 3):

1. Consider the Haar Scaling Function  $\phi(t)$ . Show that the Haar scaling function and the wavelet function  $\psi(t)$  are orthogonal to each other. Prove that the Haar wavelet  $\psi(t)$  can be represented as a linear combination of the scaling functions at a higher resolution using the relation:

$$\psi(t) = \sum_n g[n] \sqrt{2} \phi(2t - n)$$

2. Derive the Scaling Equation (Dilation Equation) and the Wavelet Equation. Show how these equations lead to the definition of the low-pass filter  $h[n]$  and high-pass filter  $g[n]$  in a DWT filter bank.

**Course Outcome 4 (CO 4):**

1. Define Biorthogonal Wavelet Systems. Contrast the signal representation in a biorthogonal system with that of an orthogonal system. Why is the symmetry of filter coefficients important in image processing?
2. Explain the Frequency Domain Characterization of filter coefficients. Given the product filter  $P(z) = H_0(z)G_0(z)$ , show how it relates to the no-aliasing condition.

**Course Outcome 5 (CO 5):**

1. Contrast the Discrete Wavelet Transform (DWT) with the Wavelet Packet Transform (WPT). Draw the complete decomposition tree for a 3-level Wavelet Packet and explain how it provides a more flexible time-frequency tiling.
2. Describe the Embedded Zero-tree Wavelet (EZW) coding algorithm. Explain the concept of "Parent-Child" relationships across different scales and how "Zero-trees" lead to efficient image compression.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 2**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, NOVEMBER 2027**

***Course Code: B24ECH73***

***Course Name: MULTIRATE SIGNAL PROCESSING AND WAVELETS***

**Max. Marks: 100**

**Duration: 3 hours**

***PART A***

***Answer all questions. Each question carries 3 marks***

1. Define decimation and interpolation in multirate systems.?
2. What are the Noble identities?
3. Define Continuous Wavelet Transform (CWT).?
4. What is dyadic discretization in wavelet transform?
5. Define Multiresolution Analysis (MRA).?
6. What is Haar wavelet?
7. Define biorthogonal wavelets.?
8. When will you go for biorthogonal wavelet transforms rather than orthogonal wavelet transform. Specify any one application where biorthogonal wavelet transform is used.
9. What are the advantages of Wavelet Packet Transform over Wavelet Transform?
10. Give a block schematic of 2-D wavelet decomposition and explain the construction of image subbands.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Show that the decimator and interpolator are linear time-varying systems.? (7)  
b) For the system shown below, find the expression for  $y(n)$  in terms of  $x(n)$ .

$$x(n) \rightarrow \uparrow 3 \rightarrow \downarrow 2 \rightarrow \downarrow 3 \rightarrow \uparrow 2 \rightarrow y(n) \quad (7)$$

12. a) Draw the block diagram of a 2-channel Quadrature Mirror Filterbank (QMF) and derive the expression for the output using z-domain analysis. What is the condition for alias cancellation? How will you construct an alias free QMF? (14)

**Module II**

13. a) Derive Heisenberg's uncertainty principle relating the time and frequency resolutions. Prove that if the window function is Gaussian, equality holds.? (7)  
b) Briefly explain the difference between Fourier Transform, Short Time Fourier Transform (STFT) & Wavelet Transform.? (7)
14. a) State and prove the admissibility conditions of a wavelet.? (6)  
b) Check whether the following function is an admissible wavelet:

$$e^{-t^2} \cos\left(\frac{\pi}{2}t\right) \quad (8)$$

**Module III**

15. a) Find two-level Haar Wavelet transform using the analysis filters

$$\{h(-k)\} = \left\{\frac{1}{2}, \frac{1}{2}\right\}, \quad \{g(-k)\} = \left\{\frac{1}{2}, -\frac{1}{2}\right\}$$

for the sequence

$$[1, 0, -3, 2, 1, 0, 1, -2]$$

Remove the coefficients between  $-1$  and  $1$  from the wavelet transform and reconstruct the function. Compute the Mean Squared Error. (14)

16. a) Let  $\phi(t)$  and  $\psi(t)$  be the Haar scaling and wavelet functions. Let  $V_j$  and  $W_j$  be the spaces spanned by

$$\phi_{j,k}(t) = 2^{j/2}\phi(2^j t - k)$$

$$\psi_{j,k}(t) = 2^{j/2}\psi(2^j t - k)$$

Let  $f(t)$  be defined for  $0 \leq t < 1$  as

$$f(t) = \begin{cases} -1 & 0 \leq t < \frac{1}{4} \\ 4 & \frac{1}{4} \leq t < \frac{1}{2} \\ 2 & \frac{1}{2} \leq t < \frac{3}{4} \\ -3 & \frac{3}{4} \leq t < 1 \end{cases}$$

- i. Express  $f$  in terms of the basis for  $V_2$ .
- ii. Decompose  $f$  into its components in  $W_1$ ,  $W_0$  and  $V_0$ .
- iii. Sketch each of the decompositions.

(14)

#### Module IV

17. a) Prove that in a Biorthogonal Wavelet System

$$\sum_k h(k) = \sum_k \tilde{h}(k) = 2$$

$$\sum_k \tilde{h}(k)h(k - 2l) = \delta_{l,0}$$

(14)

- b) Construct db2 wavelet using time domain approach.?

(14)

18. a) Explain the principle of ultrasound imaging.?

(7)

- b) Discuss the working of Magnetic Resonance Imaging (MRI).?

(7)

#### Module V

19. a) Discuss the application of wavelet analysis in Audio Coding and Signal Denoising. Compare wavelet based denoising technique with FFT based denoising method?

(14)

20. a) Explain the Embedded Zero-tree Wavelet (EZW) algorithm used in image compression.?

(7)

- b) For the seven-level decomposition shown below

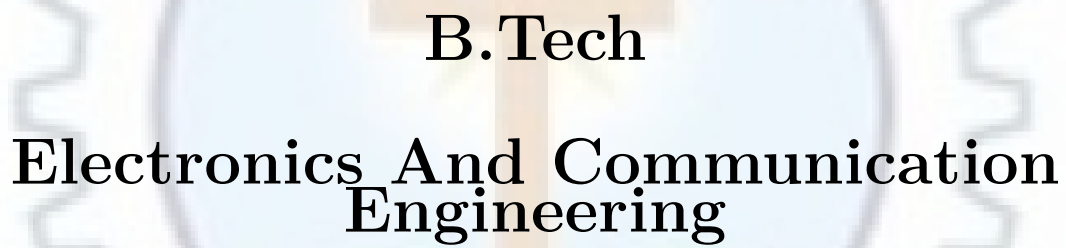
$$\begin{array}{cccc} 21 & 6 & 15 & 12 \\ -6 & 3 & 6 & 3 \\ 3 & -3 & 0 & -3 \\ 3 & 0 & 0 & 0 \end{array}$$

Find the bit stream or labels generated by the EZW coder after three steps of the multiple-pass procedure. Also determine the list of significant coefficients.?

(8)

# **MAR ATHANASIUS COLLEGE OF ENGINEERING**

Government Aided, Autonomous Institution, Kothamangalam, Kerala,  
India

The logo of Mar Athanasius College of Engineering is a circular emblem. It features a large gear-like outer border. Inside the circle, there is a blue sky with a white cross in the center. Below the cross are green hills. At the bottom of the emblem is an open book. The text 'B.Tech' is written in the center of the circle, and 'Electronics And Communication Engineering' is written below it.

## **B.Tech Electronics And Communication Engineering**

### **SEMESTER 8**

#### **SYLLABUS**



**SEMESTER 8**

| SLOT         | COURSE NO. | COURSES                               | L-T-P-S  | HOURS     | CREDIT    |
|--------------|------------|---------------------------------------|----------|-----------|-----------|
| A,B,C        | B24MC400X  | INTERNSHIP & MOOC COURSES (3 NUMBERS) | 0-0-0-0  | 0         | 9         |
| OR           |            |                                       |          |           |           |
| A            | B24EC4P5X  | PROGRAMME ELECTIVE V                  | 2-1-0-4  | 3         | 3         |
| B            | B24EC4P6X  | PROGRAMME ELECTIVE VI                 | 2-1-0-4  | 3         | 3         |
| C            | B24EC4G3X  | OPEN ELECTIVE III                     | 2-1-0-4  | 3         | 3         |
| AND          |            |                                       |          |           |           |
| H            | B24EC4L14  | PROJECT PHASE 2                       | 0-0-12-3 | 12        | 6         |
| M            | B24ECML8X  | MINOR PROJECT                         | 0-0-3-12 | 3         | 6         |
| N            | B24ECHL8X  | HONOURS PROJECT                       | 0-0-6-9  | 6         | 6         |
| <b>TOTAL</b> |            |                                       |          | <b>30</b> | <b>15</b> |

**PROGRAMME ELECTIVE V**

| COURSE NO | Courses                     |
|-----------|-----------------------------|
| B24EC4P51 | REAL TIME OPERATING SYSTEMS |
| B24EC4P52 | MEDICAL ELECTRONICS         |
| B24EC4P53 | RADIATION AND PROPAGATION   |
| B24EC4P54 | OPTIMIZATION TECHNIQUES     |
| B24EC4P55 | ERROR CONTROL CODES         |

**PROGRAMME ELECTIVE VI**

| COURSE NO | Courses                 |
|-----------|-------------------------|
| B24EC4P61 | DATA ANALYTICS          |
| B24EC4P62 | PATTERN RECOGNITION     |
| B24EC4P63 | LOW POWER VLSI          |
| B24EC4P64 | COMPUTER VISION         |
| B24EC4P65 | SATELLITE COMMUNICATION |

**OPEN ELECTIVE III**

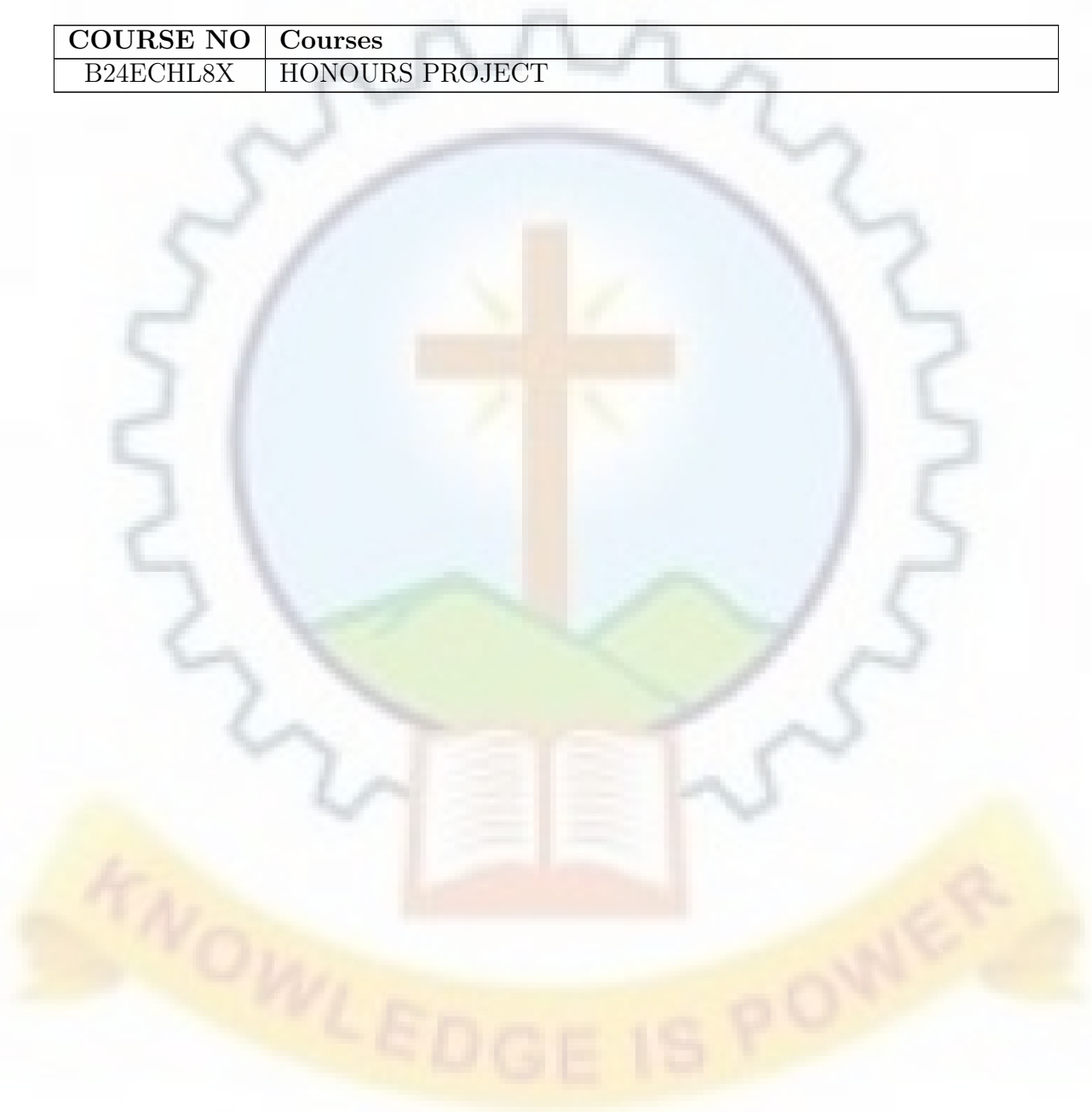
| COURSE NO | Courses                     |
|-----------|-----------------------------|
| B24EC4G31 | MACHINE LEARNING            |
| B24EC4G32 | ROBOTICS                    |
| B24EC4G33 | REAL TIME OPERATING SYSTEMS |
| B24EC4G34 | MECHATRONICS                |
| B24EC4G35 | ENTREPRENEURSHIP            |

**MINOR**

| <b>COURSE NO</b> | <b>Courses</b> |
|------------------|----------------|
| B24ECML8X        | MINOR PROJECT  |

**HONOURS**

| <b>COURSE NO</b> | <b>Courses</b>  |
|------------------|-----------------|
| B24ECHL8X        | HONOURS PROJECT |



| B24EC4P51 | REAL TIME<br>OPERATING<br>SYSTEMS | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|-----------------------------------|---|---|---|---|--------|-------------------------|
|           |                                   | 2 | 1 | 0 | 4 | 3      | 2024                    |

### Preamble

This introductory course provides an overview of Real-Time Operating Systems, starting from fundamental operating system concepts. It focuses on real-time principles, scheduling, and system design relevant to embedded and real-time applications.

### Prerequisites

B24EC2T02 : COMPUTER ARCHITECTURE AND MICROCONTROLLERS

### Course Outcomes

After the completion of the course, the student will be able to:

|      |                                                                                                                                                                                                                                        |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Explain and summarize the fundamental concepts, architectures, and evolution of operating systems, including process management and system types. [Understand]                                                                         |
| CO 2 | Analyze and compare process and thread scheduling algorithms and multithreading models to evaluate their suitability for different system requirements. [Analyze]                                                                      |
| CO 3 | Explain real-time system requirements and mechanisms, including task management, synchronization, communication, interrupt handling and apply these in the context of electronics and embedded applications. [Understand]              |
| CO 4 | Evaluate the real-time scheduling algorithms, task constraints, and synchronization protocols to determine feasibility and correctness of real-time systems. [Evaluate]                                                                |
| CO 5 | Analyze and assess practical real-time system design aspects, including memory and I/O management, WCET analysis, reliability considerations, and the applicability of commercial RTOS in embedded electronics applications. [Analyze] |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    | 1    | 1    |      |      |      | 1    | 1    | 1     | 1     |
| CO 2 | 2    | 3    | 2    | 2    |      |      |      | 1    | 1    | 1     | 1     |
| CO 3 | 2    | 3    | 2    | 3    | 1    | 1    |      | 1    | 1    | 1     | 1     |
| CO 4 | 2    | 3    | 3    | 3    | 1    | 1    |      | 1    | 1    | 1     | 1     |
| CO 5 | 2    | 3    | 2    | 3    | 2    | 2    | 1    | 1    | 1    | 1     | 1     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         |                       |                 |                                    |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          | 10                    | 10              | 10                                 |
| Evaluate         | 10                    | 10              | 10                                 |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions

from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.



## SYLLABUS

### MODULE 1

**Introduction to Operating Systems:** Operating system: Definition, Objectives and Functions. Kernel mode, User mode. Evolution of operating systems. Types of systems: Batch, Multiprogramming, Multiprocessing, Time-sharing, Parallel, Distributed, Real time systems. OS Architecture: Monolithic kernels, Micro kernels, Layered architecture, Virtual machines, Hybrid kernels. Basic OS concepts: Processes, Process Control Block Process states and state transitions, Operations on processes, Context switching.

### MODULE 2

**Process scheduling:** Scheduling algorithms, Levels of scheduling algorithms, Design goals. Types – Pre-emptive and Non-preemptive algorithms. Types of algorithms – First Come First Serve, Shortest Job First, Smallest Remaining Time First, Priority Based, Round Robin, Multilevel Queue and Multilevel Feedback Queue Scheduling, multiprocessor scheduling. Thread: Structure, User and kernel level threads, multi-threading models.

### MODULE 3

**Real time systems:** General-purpose OS and Real-Time OS - comparison. Definition and characteristics of real-time systems. Classification of real-time systems: Hard, Soft real-time systems Real Time Operating Systems: Structure, components and characteristics of Real Time Systems. Real-time performance metrics. Real-time system applications in electronics and embedded domains. Task: Task states, Task synchronization -Semaphores- types Inter task communication mechanisms: shared memory, message passing, message queues, pipes, event registers, signals, Exceptions and interrupt handling.

### MODULE 4

**Scheduling in Real time systems:** Real-time considerations in sensor-actuator systems. Real-time tasks and task models, Task constraints – timing, precedence and resource constraints. Scheduling criteria and feasibility. Priority inversion, Priority Inheritance Protocol, Highest Locker Protocol, Priority Ceiling Protocol. Task scheduling: Aperiodic task scheduling: EDD, EDF, LDF, EDF with precedence constraints. Periodic task scheduling: Rate monotonic and Deadline monotonic. Basic principles of Deadlock.

### MODULE 5

**Real time systems for practical systems:** Memory management requirements – Memory



partitioning – Fixed and Dynamic partitioning. I/O management in real time systems – Port mapped, Memory mapped I/O, DMA. Watchdog timers and system safety. Reliability and fault tolerance concepts. Worst-Case Execution Time (WCET) Analysis. Commercial real time operating systems: Features only – Free RTOS, MicroC/OS-II, PSOS, VRTX, RT Linux- Features and applications. Real-time system applications in electronics and embedded control domains. Case Study: RTOS control system in adaptive cruise control.

**Text Books**

1. Abraham Silberschatz, Operating System Principles, Wiley India
2. William Stallings, Operating systems- Internals and design principles, Prentice Hall
3. Qing Li, Real-Time Concepts for Embedded Systems, CMP Books
4. Andrew S. Tanenbaum, Modern Operating Systems, Pearson
5. Rajib Mall, Real-Time Systems: Theory and Practice, Pearson
6. Raj Kamal, Embedded Systems – Architecture, Programming and Design, Tata McGraw Hill

**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                                                                              | <b>No of Lecture/Tutorial Hours</b> |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                                                                                           | <b>7</b>                            |
| 1.1       | Operating system: Definition, Objectives and Functions.                                                                                                                   | 1                                   |
| 1.2       | Kernel mode, User mode.                                                                                                                                                   | 1                                   |
| 1.3       | Evolution of operating systems.                                                                                                                                           | 1                                   |
| 1.4       | Types of systems: Batch, Multiprogramming, Multiprocessing, Time-sharing, Parallel, Distributed, Real time system.                                                        | 1                                   |
| 1.5       | OS Architecture: Monolithic kernels, Micro kernels, Layered architecture, Virtual machines, Hybrid kernels.                                                               | 1                                   |
| 1.6       | Basic OS concepts: Processes, Process Control Block.                                                                                                                      | 1                                   |
| 1.7       | Process states and state transitions, Operations on processes, Context switching.                                                                                         | 1                                   |
|           | <b>Module 2</b>                                                                                                                                                           | <b>7</b>                            |
| 2.1       | Scheduling algorithms, Levels of scheduling algorithms, Design goals.                                                                                                     | 1                                   |
| 2.2       | Types – Pre-emptive and Non-preemptive algorithms.                                                                                                                        | 1                                   |
| 2.3       | Types of algorithms – First Come First Serve, Shortest Job First.                                                                                                         | 1                                   |
| 2.4       | Smallest Remaining Time First, Priority Based.                                                                                                                            | 1                                   |
| 2.5       | Round Robin.                                                                                                                                                              | 1                                   |
| 2.6       | Multilevel Queue and Multilevel Feedback Queue Scheduling.                                                                                                                | 1                                   |
| 2.7       | Multiprocessor scheduling, Thread: Structure, User and kernel level threads, multi-threading models                                                                       | 1                                   |
|           | <b>Module 3</b>                                                                                                                                                           | <b>9</b>                            |
| 3.1       | General-purpose OS and Real-Time OS - comparison. Definition and characteristics of real-time systems. Classification of real-time systems: Hard, Soft real-time systems. | 1                                   |
| 3.2       | Real Time Operating Systems: Structure, components and characteristics of Real Time Systems.                                                                              | 1                                   |
| 3.3       | Real-time performance metrics. Real-time system applications in electronics and embedded domains.                                                                         | 1                                   |
| 3.4       | Task: Task states.                                                                                                                                                        | 1                                   |
| 3.5       | Task synchronization -Semaphores- types.                                                                                                                                  | 2                                   |
| 3.6       | Inter task communication mechanisms: shared memory, message passing.                                                                                                      | 1                                   |
| 3.7       | Message queues, pipes.                                                                                                                                                    | 1                                   |
| 3.8       | Event registers, signals, Exceptions and interrupt handling.                                                                                                              | 1                                   |
|           | <b>Module 4</b>                                                                                                                                                           | <b>9</b>                            |

|     |                                                                                                                                                      |                 |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 4.1 | Real-time considerations in sensor-actuator systems. Real-time tasks and task models, Task constraints – timing, precedence and resource constraint. | 1               |
| 4.2 | Scheduling criteria and feasibility.                                                                                                                 | 1               |
| 4.3 | Priority inversion, Priority Inheritance Protocol, Highest Locker Protocol, Priority Ceiling Protocol.                                               | 1               |
| 4.4 | Task scheduling: Aperiodic task scheduling: EDD.                                                                                                     | 1               |
| 4.5 | EDF, LDF                                                                                                                                             | 1               |
| 4.6 | EDF with precedence constraints.                                                                                                                     | 1               |
| 4.7 | Periodic task scheduling: Rate monotonic and Deadline monotonic                                                                                      | 2               |
| 4.8 | Basic principles of Deadlock.                                                                                                                        | 1               |
|     | <b>Module 5</b>                                                                                                                                      | <b>6</b>        |
| 5.1 | Memory management requirements – Memory partitioning – Fixed and Dynamic partitioning.                                                               | 1               |
| 5.2 | I/O management in real time systems – Port mapped, Memory mapped I/O, DMA. Watchdog timers and system safety.                                        | 1               |
| 5.3 | Reliability and fault tolerance concepts. Worst-Case Execution Time (WCET) Analysis.                                                                 | 1               |
| 5.4 | Commercial real time operating systems: Features only – Free RTOS, MicroC/OS-II, PSOS, VRTX, RT Linux- Features and applications.                    | 2               |
| 5.5 | Real-time system applications in electronics and embedded control domains. Case Study: RTOS control system in adaptive cruise control.               | 1               |
|     | <b>Total Hours</b>                                                                                                                                   | <b>38 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain process state model in detail with the help of state transition diagrams.
2. Describe the key functionalities of an operating system.

#### Course Outcome 2 (CO 2):

1. Compare Shortest Job First scheduling and Shortest Remaining Time First Scheduling algorithms in terms of average waiting time and average turnaround time for a set of five process with process IDs P1, P2, P3, P4, P5 with estimated execution time 1,4,2,6,3 milliseconds respectively. If these processes arrive in the ready queue in the order P4, P2, P5, P1, P3 with an interval of 1ms.

2. Explain the concept of load balancing in symmetric multiprocessing systems? What are the techniques to perform load balancing?

**Course Outcome 3 (CO 3):**

1. Explain semaphores and its associated data structures. Also explain different types of semaphores.
2. Explain message queue and pipe inter task communication mechanisms in RTOS. Also list any two differences between pipes and message queues.

**Course Outcome 4 (CO 4):**

1. Given seven tasks, A, B, C, D, E, F, and G. Construct the precedence graph from the following precedence relations:  $A \rightarrow C$ ;  $B \rightarrow C$ ;  $B \rightarrow D$ ;  $C \rightarrow E$ ;  $C \rightarrow F$ ;  $D \rightarrow F$ ;  $D \rightarrow G$ . Assuming that all tasks arrive at time  $t = 0$ , all tasks deadline  $D = 25$ , and computation times 2, 3, 3, 5, 1, 2, 5, respectively. Modify their arrival times and deadlines to schedule them by EDF with precedence constraints.
2. Explain the timing constraints of a Real Time Operating System.

**Course Outcome 5 (CO 5):**

1. With a suitable requirement table and block diagram explain the real time operating system used in an adaptive cruise control system.
2. Explain the features of RT Linux RTOS.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2028**

**Course Code: B24EC4P51**

**Course Name: REAL TIME OPERATING SYSTEMS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Explain the services offered by kernel in an operating system.
2. What is a process and draw the structure of process memory.
3. List any three scheduling criteria.
4. Explain the concept of processor affinity.
5. Sketch and explain the structure of RTOS.
6. Explain different types RTOS based on the deadline.
7. Differentiate between periodic and aperiodic task.
8. Explain LDF scheduling algorithm.
9. Explain any 3 features of free RTOS.
10. List any 3 applications of RTLinux.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) With the help of suitable diagrams, compare monolithic, layered and micro-kernel architecture of operating systems. (9)  
b) Justify the significance of “time slicing” in modern operating system. (5)
12. a) Draw the structure of a process control block in memory. Explain the significance of process control block. (7)  
b) With the help of state transition diagrams, explain various state of a process and its transition. (7)

### Module II

13. a) Draw the Gantt chart for the round robin scheduling algorithm and shortest job first algorithm. Find the average waiting time and turn-around time. Determine which algorithm will be most suitable for the given set of process. Assume time slice of 2ms. (7)

| Process | Burst Time (ms) |
|---------|-----------------|
| P1      | 10              |
| P2      | 4               |
| P3      | 2               |
| P4      | 1               |
| P5      | 5               |

- b) Differentiate between multilevel queue and multilevel feedback queue scheduling. (7)
14. a) With the help of example, differentiate between Shortest Job First and Smallest Remaining Time First algorithm. Explain the suitability of these algorithms for preemptive and non-preemptive scheduling. (9)  
b) Differentiate between a process and a thread. Explain the significance of threads in a computing scenario. (5)

### Module III

15. a) Explain semaphores and its significance. Explain different types of semaphores with its state transition diagram. (9)  
b) Differentiate between a message queue and a message pipe. (5)
16. a) Explain the structure and components of a real time system. Differentiate between hard and soft real time systems. (7)  
b) Explain the need for mutual exclusion. How is it achieved in operating systems. (7)

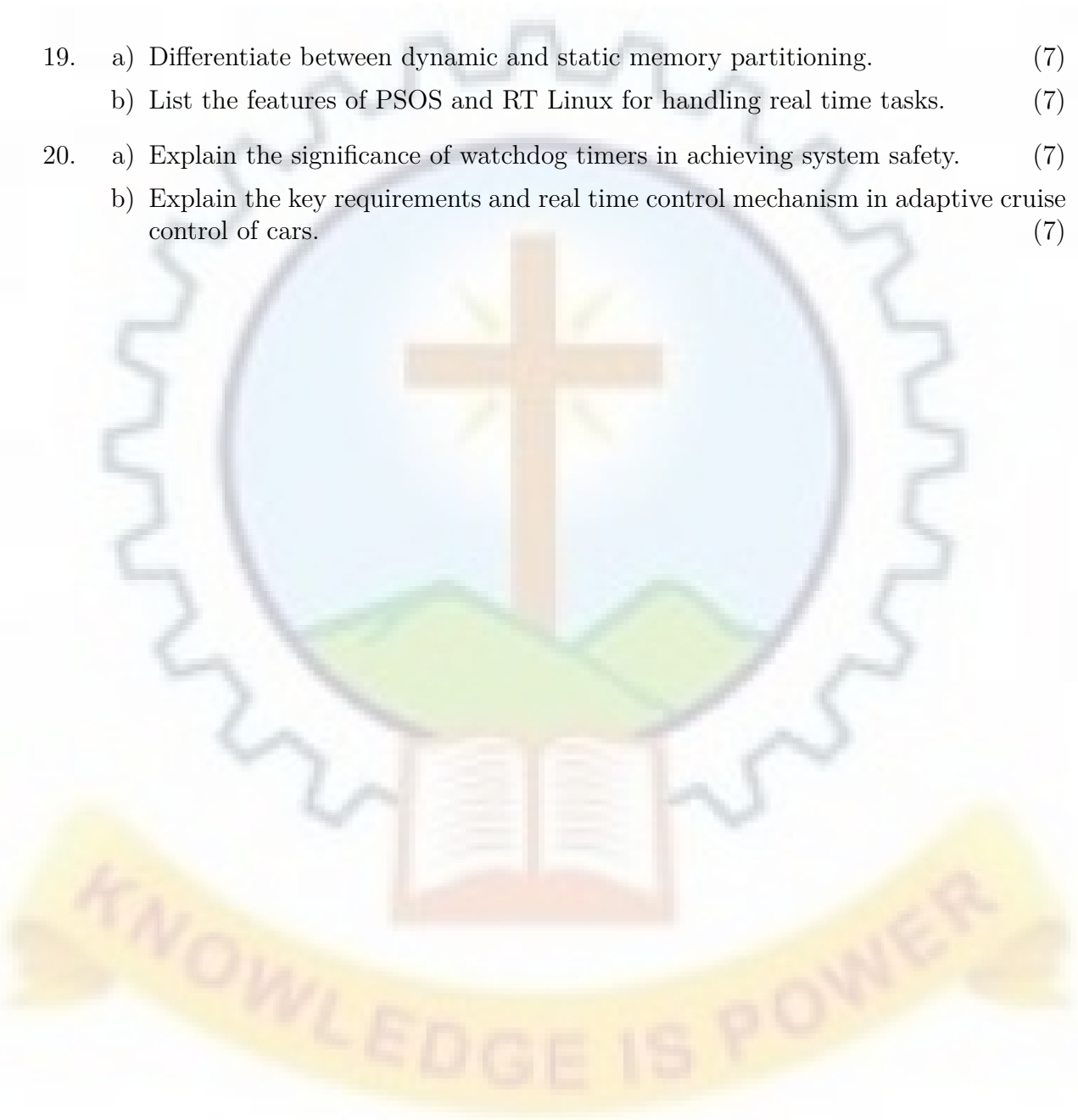
### Module IV



17. Describe various task constraints that needs to be taken into consideration while designing a real time system. (14)
18. Explain Earliest Due Date algorithm. With the help of an example, prove that EDD is optimal in minimizing maximum lateness of tasks. (14)

**Module V**

19.
  - a) Differentiate between dynamic and static memory partitioning. (7)
  - b) List the features of PSOS and RT Linux for handling real time tasks. (7)
20.
  - a) Explain the significance of watchdog timers in achieving system safety. (7)
  - b) Explain the key requirements and real time control mechanism in adaptive cruise control of cars. (7)



| B24EC4P52 | MEDICAL<br>ELECTRONICS | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|------------------------|---|---|---|---|--------|-------------------------|
|           |                        | 2 | 1 | 0 | 4 | 3      | 2024                    |

### Preamble

This course applies electronic principles to healthcare for monitoring, diagnosis, and treatment. This course introduces biomedical signals, sensors, medical instrumentation, imaging systems, and therapeutic devices used in modern healthcare applications.

**Prerequisites:** B24EC1T04 Analog Circuits I

B24EC2T05 Signals and Systems

B24EC2T06 Linear Integrated Circuits

### Course Outcomes

After the completion of the course, the student will be able to:

|             |                                                                                                                                           |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the basic physiological systems and bioelectric signals used in biomedical instrumentation. [Understand]                       |
| <b>CO 2</b> | Apply biomedical sensors and transducers to measure physiological parameters such as temperature, blood pressure and respiration. [Apply] |
| <b>CO 3</b> | Apply principles of ECG, EEG and EMG systems for bioelectric signal acquisition and analysis. [Apply]                                     |
| <b>CO 4</b> | Analyse the working principles of medical imaging systems such as X-ray, CT, Ultrasound and MRI. [Analyse]                                |
| <b>CO 5</b> | Analyse the operation of therapeutic and life-support medical devices and evaluate their role in modern healthcare systems. [Analyse]     |

### Mapping of Course Outcomes With Program Outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 2    |      |      | 1    |      |      |      |      |       | 1     |
| <b>CO 2</b> | 2    | 3    | 1    | 2    | 2    |      |      |      |      |       | 1     |
| <b>CO 3</b> | 2    | 3    | 1    | 2    | 2    |      |      |      |      |       | 1     |
| <b>CO 4</b> | 2    | 3    |      | 2    | 2    |      |      |      |      |       | 1     |
| <b>CO 5</b> | 2    | 3    | 1    | 2    | 2    | 1    |      |      |      |       | 1     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 10                    | 10                 | 10                                    |
| Understand       | 20                    | 20                 | 40                                    |
| Apply            | 20                    | 20                 | 50                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Physiological Systems and Biomedical Signals:** Review of basic human physiology relevant to medical electronics, bioelectric potentials and origin of bioelectric signals, characteristics of biomedical signals, biomedical instrumentation system, components of biomedical instrumentation, electrodes and electrode–tissue interface, problems in biomedical signal measurement.

### MODULE 2

**Biomedical Sensors and Measurement Systems:** Biomedical transducers and sensors, classification of biomedical sensors, measurement of physiological parameters – body temperature, blood pressure, respiration, blood flow, pulse rate measurement, signal conditioning circuits for biomedical signals, noise and interference in biomedical measurements.

### MODULE 3

**Bioelectric Signal Measurement Systems:** Electrocardiography (ECG) – principles and instrumentation, ECG leads and recording systems, Electroencephalography (EEG) – measurement of brain signals, Electromyography (EMG) – muscle signal measurement, Phonocardiography (PCG), biomedical signal acquisition and recording systems.

### MODULE 4

**Medical Imaging Systems:** X-ray imaging systems, Computed Tomography (CT), Ultrasound imaging systems, Magnetic Resonance Imaging (MRI), nuclear medical imaging techniques, basic principles of medical image acquisition and processing.

### MODULE 5

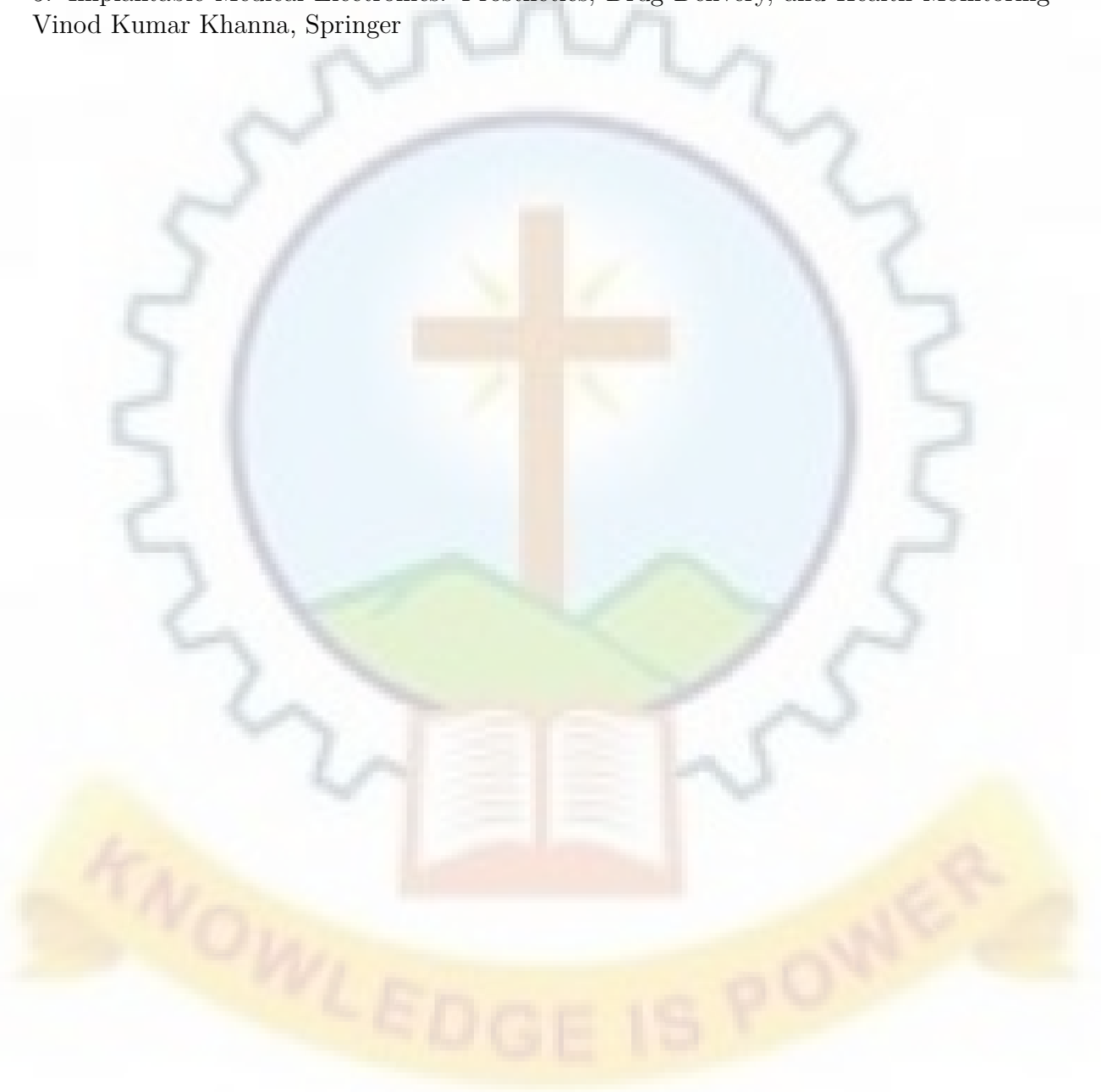
**Therapeutic and Life-Support Devices:** Cardiac pacemakers, defibrillators, ventilators and anesthesia machines, hemodialysis machine, patient monitoring systems, biomedical telemetry, electrical safety in medical equipment and patient protection methods.

### Text Books

1. Handbook of Biomedical Instrumentation – R. S. Khandpur, McGraw-Hill Education.
2. Medical Instrumentation: Application and Design – John G. Webster and Amit J. Nimunkar, Wiley.

**Reference Books**

1. Introduction to Biomedical Instrumentation and Its Applications – Sudip Paul et al., Elsevier.
2. Biomedical Instrumentation: Concepts, Technologies, and Future Innovations – Almir Badnjević et al., Springer.
3. Instrumentation Handbook for Biomedical Engineers – Mesut Sahin et al., CRC Press.
4. Jochen Schiller - Mobile Communications- Pearson Education
5. Implantable Medical Electronics: Prosthetics, Drug Delivery, and Health Monitoring – Vinod Kumar Khanna, Springer



**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                                                                  | <b>No of Lecture/Tutorial Hours</b> |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                                                                               | <b>7</b>                            |
| 1.1       | Review of basic human physiology relevant to medical electronics, bioelectric potentials and origin of bioelectric signals                                    | 2                                   |
| 1.2       | Characteristics of biomedical signals, biomedical instrumentation system                                                                                      | 2                                   |
| 1.3       | Components of biomedical instrumentation                                                                                                                      | 2                                   |
| 1.4       | Problems in biomedical signal measurement                                                                                                                     | 1                                   |
|           | <b>Module 2</b>                                                                                                                                               | <b>7</b>                            |
| 2.1       | Biomedical transducers and sensors, classification of biomedical sensors                                                                                      | 2                                   |
| 2.2       | Measurement of physiological parameters – body temperature and blood pressure                                                                                 | 2                                   |
| 2.3       | Measurement of respiration, blood flow and pulse rate, Signal conditioning circuits for biomedical signals, noise and interference in biomedical measurements | 3                                   |
|           | <b>Module 3</b>                                                                                                                                               | <b>7</b>                            |
| 3.1       | Electrocardiography (ECG) – principles and instrumentation, ECG leads and recording systems                                                                   | 3                                   |
| 3.2       | Electroencephalography (EEG) and Electromyography (EMG) measurement systems                                                                                   | 2                                   |
| 3.3       | Phonocardiography (PCG) and biomedical signal acquisition and recording systems                                                                               | 2                                   |
|           | <b>Module 4</b>                                                                                                                                               | <b>7</b>                            |
| 4.1       | X-ray imaging systems and basic principles of medical image acquisition                                                                                       | 2                                   |
| 4.2       | Computed Tomography (CT)                                                                                                                                      | 1                                   |
| 4.3       | Ultrasound imaging systems, Magnetic Resonance Imaging (MRI) and nuclear medical imaging techniques                                                           | 4                                   |
|           | <b>Module 5</b>                                                                                                                                               | <b>7</b>                            |
| 5.1       | Cardiac pacemakers and defibrillators                                                                                                                         | 2                                   |
| 5.2       | Ventilators and anesthesia machines                                                                                                                           | 2                                   |
| 5.3       | Hemodialysis machine and patient monitoring systems                                                                                                           | 2                                   |
| 5.4       | Biomedical telemetry, electrical safety in medical equipment and patient protection methods                                                                   | 1                                   |
|           | <b>Total Hours</b>                                                                                                                                            | <b>35 Hours</b>                     |



## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1):**

1. Explain the origin of bioelectric potentials and describe the characteristics of biomedical signals.
2. Explain the block diagram of a biomedical instrumentation system and discuss its main components.

### **Course Outcome 2 (CO 2):**

1. Explain the classification of biomedical sensors and discuss their applications in physiological parameter measurement.
2. Describe the methods used to measure body temperature and blood pressure using biomedical sensors.

### **Course Outcome 3 (CO 3):**

1. Explain the working principle and instrumentation of an Electrocardiograph (ECG).
2. Describe the principles and applications of EEG and EMG signal measurement systems.

### **Course Outcome 4 (CO 4):**

1. Explain the principle and working of X-ray imaging and CT scan systems.
2. Compare the working principles of ultrasound imaging and MRI systems.

### **Course Outcome 5 (CO 5):**

1. Explain the working principle and applications of cardiac pacemakers and defibrillators.
2. Describe the working of a hemodialysis machine and discuss the importance of patient monitoring systems in healthcare.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 2**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2028**

***Course Code: B24EC4P52***

***Course Name: MEDICAL ELECTRONICS***

**Max. Marks: 100**

**Duration: 3 hours**

***PART A***

***Answer all questions. Each question carries 3 marks***

1. Define bioelectric potential.
2. What are biomedical electrodes?
3. List the types of biomedical sensors.
4. What is signal conditioning in biomedical instrumentation?
5. What are ECG leads?
6. Define EEG and EMG.
7. What is X-ray imaging?
8. What is Computed Tomography (CT)?
9. Define pacemaker.
10. What is biomedical telemetry?

**PART B**

***Answer any one question from each module. Each question carries 14 marks***

***Module I***

11. a) Explain the origin of bioelectric signals and their characteristics.? (7)  
b) Explain the block diagram of a biomedical instrumentation system and discuss its components.? (7)
12. a) Explain the electrode–tissue interface in biomedical measurements? (6)  
b) Discuss the problems encountered in biomedical signal measurement and methods to minimize them.? (8)

***Module II***

13. a) Explain the classification of biomedical sensors with suitable examples? (6)  
b) Describe the methods used to measure body temperature and blood pressure.? (8)
14. a) Explain the principle of respiration measurement.? (6)  
b) Discuss the measurement of blood flow and pulse rate using biomedical sensors.? (8)

***Module III***

15. a) Explain the principle of Electrocardiography (ECG)? (6)  
b) Describe ECG lead configurations and recording systems.? (8)
16. a) Explain the working principle of EEG.? (6)  
b) Describe the instrumentation used in EMG signal measurement.? (8)

***Module IV***

17. a) Explain the basic principle of X-ray imaging? (6)  
b) Describe the working principle of Computed Tomography (CT).? (8)
18. a) Explain the principle of ultrasound imaging.? (7)  
b) Discuss the working of Magnetic Resonance Imaging (MRI).? (7)

***Module V***

19. a) Explain the working principle of cardiac pacemakers.? (6)  
b) Describe the working of defibrillators and their applications.? (8)
20. a) Explain the working principle of a hemodialysis machine.? (6)  
b) Discuss the importance of electrical safety in medical equipment.? (8)

| <b>B24EC4P53</b> | <b>RADIATION<br/>AND<br/>PROPAGATION</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF<br/>INTRODUCTION</b> |
|------------------|------------------------------------------|----------|----------|----------|----------|---------------|---------------------------------|
|                  |                                          | 2        | 1        | 0        | 4        |               |                                 |

**Preamble**

Building upon the foundation of Maxwell's equations and wave equations from the prerequisite course, this elective focuses on the mechanisms by which electromagnetic energy is radiated into space and how it propagates through various terrestrial and atmospheric media. The course covers antenna fundamentals, features of different types of antennas and arrays, and the physical phenomena governing radio wave propagation.

**Prerequisites**

B24EC3T06 : Electromagnetic Theory

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                           |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Summarize the fundamental radiation mechanisms and define key antenna parameters such as directivity, gain, and radiation resistance. [Understand, Comprehend]            |
| <b>CO 2</b> | Analyze the electromagnetic field distributions and radiation characteristics of infinitesimal, short, and half-wave dipole antennas. [Understand, Apply]                 |
| <b>CO 3</b> | Illustrate the operational principles and design constraints of aperture, reflector, and modern microstrip patch antennas for wireless applications. [Understand, Apply]  |
| <b>CO 4</b> | Evaluate the performance of antenna arrays and synthesize array factors for uniform and non-uniform configurations to achieve specific beam patterns. [Analyze, Evaluate] |
| <b>CO 5</b> | Calculate critical system parameters for radio wave propagation, including MUF, skip distance, and LOS range across different atmospheric layers. [Understand, Apply]     |

**Mapping of Course Outcomes With Program Outcomes**

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    |      |      |      |      |      |      |      |       | 2     |
| CO 2 | 3    | 3    |      |      |      | 1    |      |      |      |       | 2     |
| CO 3 | 3    | 3    | 3    | 2    | 3    | 2    |      |      |      |       | 3     |
| CO 4 | 3    | 2    | 3    |      |      | 3    |      |      |      |       | 2     |
| CO 5 | 3    | 3    |      |      |      | 1    |      |      |      |       | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Antenna Fundamentals and Radiation Mechanism:** Antenna Radiation Mechanism, Concept of Retarded potential, Radiation from an oscillating Hertzian Dipole, Antenna Parameters: Radiation Pattern (Isotropic, Directional, Omnidirectional), Radiation Intensity, Beamwidth (HPBW, FNBW), Directivity, Gain, Efficiency, Fields and Impedance: Near-field and Far-field regions (Fresnel and Fraunhofer zones), Radiation Resistance, Antenna Polarization, Effective Aperture Area and Friis Transmission Equation.

### MODULE 2

**Linear Wire Antennas:** Thin Linear Wire Antennas: Current distribution on thin wires. Analysis of Infinitesimal Dipole, Short Dipole, and Half-Wave Dipole, Expressions for Radiation resistance and directivity, Field Equations: derivation of electric and magnetic field components in the far-field. Monopole Antennas: Grounding effects and Image Theory application, Loop Antennas: Small circular loops, radiation resistance, and duality with short dipoles.

### MODULE 3

**Aperture, Broadband, and Modern Antennas:** Aperture Antennas: Huygens' Principle, Slot Antennas, Horn Antennas (E-plane, H-plane, and Pyramidal), Reflector Antennas: Flat sheet reflectors, Corner reflectors, and Parabolic reflectors (Feed mechanisms and Cassegrain feed), Broadband Antennas: Helical antenna (Normal and Axial modes), Log-Periodic antennas, Microstrip Antennas: Rectangular Patch Antennas – basic characteristics and feeding methods, Familiarization of antenna simulation tool-HFSS.

### MODULE 4

**Antenna Arrays:** Array Basics: Point sources, Principle of Pattern Multiplication, Uniform Linear Arrays: Two-element arrays, N-element Broadside Array, and N-element End-Fire Array, Array Synthesis: Phased arrays, Beam steering, and Grating lobes, Non-Uniform Arrays: Introduction to Binomial Arrays and Tschebyscheff Arrays (Chebyshev).

### MODULE 5

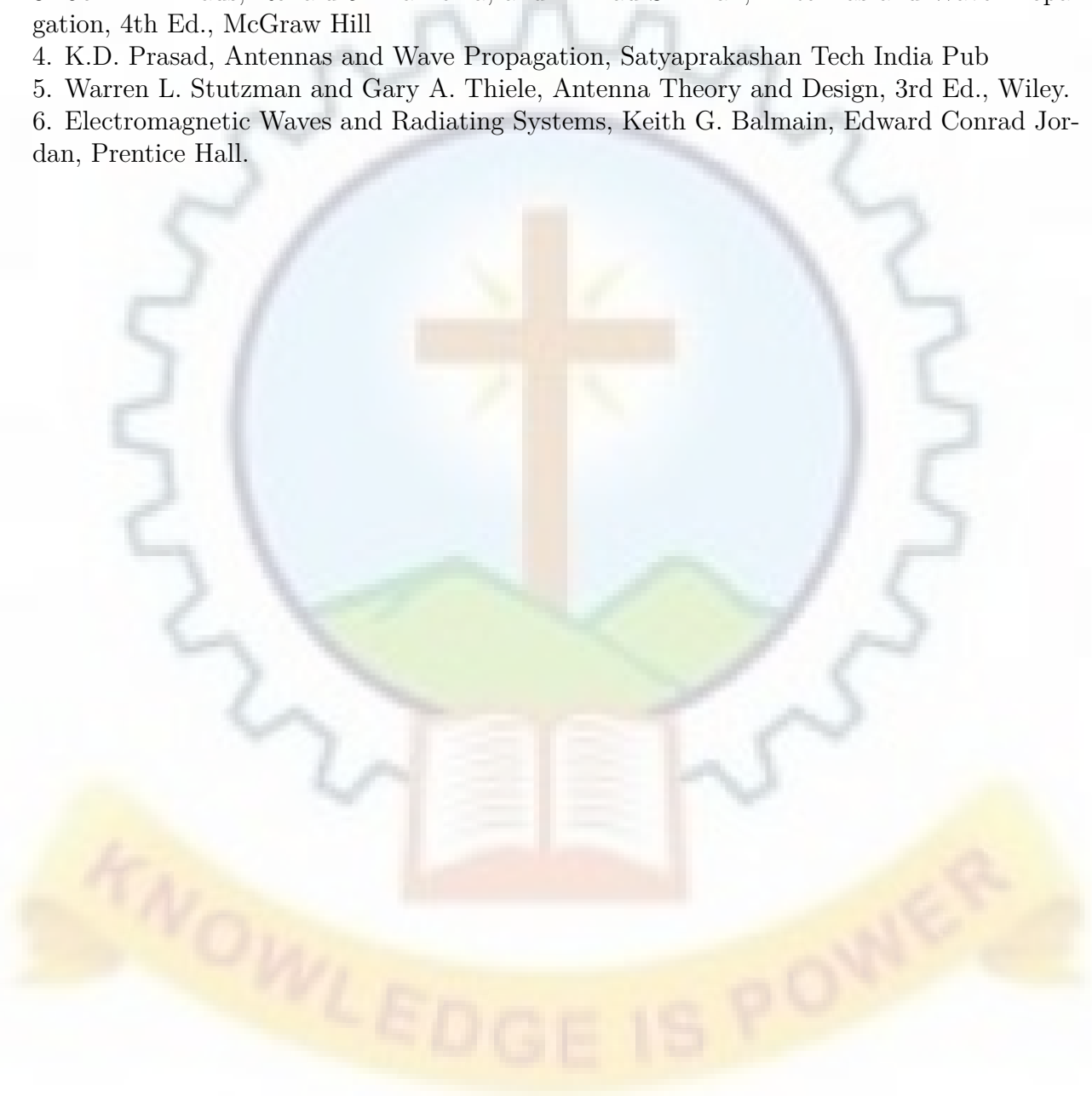
**Radio Wave Propagation:** Ground Wave Propagation: Surface waves, Earth's curvature, and tilt effects, Space Wave Propagation: Line-of-sight (LOS), Field strength calculations, Duct propagation, and Tropospheric scattering, Sky Wave Propagation: Structure of the



Ionosphere, Critical Frequency, Maximum Usable Frequency (MUF), Skip Distance, and Virtual Height.

**Text Books**

1. Antennas and Wave Propagation, G S N Raju, Pearson, 2016.
2. Constantine A. Balanis, Antenna Theory: Analysis and Design, 4th Ed., Wiley.
3. John D. Kraus, Ronald J. Marhefka, and Ahmad S. Khan, Antennas and Wave Propagation, 4th Ed., McGraw Hill
4. K.D. Prasad, Antennas and Wave Propagation, Satyaprakashan Tech India Pub
5. Warren L. Stutzman and Gary A. Thiele, Antenna Theory and Design, 3rd Ed., Wiley.
6. Electromagnetic Waves and Radiating Systems, Keith G. Balmain, Edward Conrad Jordan, Prentice Hall.



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                                   | No of Lecture/Tutorial Hours |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                                         | <b>8</b>                     |
| 1.1 | Antenna Radiation Mechanism and concept of Retarded Potential.                                                                                                          | 2                            |
| 1.2 | Radiation from an oscillating Hertzian Dipole.                                                                                                                          | 2                            |
| 1.3 | Antenna Parameters: Radiation Pattern(Isotropic, Directional, Omnidirectional), Intensity, Beamwidth (HPBW, FNBW), Directivity, Gain, Efficiency, Fields and Impedance. | 2                            |
| 1.4 | Nearfield and Far-field regions (Fresnel and Fraunhofer zones), Radiation Resistance, Antenna Polarization, Effective Aperture Area and Friis Transmission Equation.    | 2                            |
|     | <b>Module 2</b>                                                                                                                                                         | <b>8</b>                     |
| 2.1 | Thin Linear Wire Antennas: Current distribution on thin wires.                                                                                                          | 1                            |
| 2.2 | Analysis of Infinitesimal and Short Dipole.                                                                                                                             | 2                            |
| 2.3 | Analysis and Radiation resistance of Half-Wave Dipole.                                                                                                                  | 2                            |
| 2.4 | Monopole Antennas: Grounding effects and Image Theory.                                                                                                                  | 2                            |
| 2.5 | Small circular loop antennas and duality principles.                                                                                                                    | 1                            |
|     | <b>Module 3</b>                                                                                                                                                         | <b>8</b>                     |
| 3.1 | Aperture Antennas: Huygens' Principle, Slot and Horn Antennas(E-plane, H-plane, and Pyramidal).                                                                         | 2                            |
| 3.2 | Reflector Antennas: Flat, Corner, and Parabolic (Feed mechanisms and Cassegrain feed).                                                                                  | 1                            |
| 3.3 | Broadband Antennas: Helical antenna (Normal and Axial modes) and Log-Periodic antennas.                                                                                 | 2                            |
| 3.4 | Microstrip Antennas: Rectangular Patch Antennas – basic characteristics, design and feeding methods.                                                                    | 2                            |
| 3.5 | Familiarization of antenna simulation software.                                                                                                                         | 1                            |
|     | <b>Module 4</b>                                                                                                                                                         | <b>8</b>                     |
| 4.1 | Array Basics: Point sources and Principle of Pattern Multiplication.                                                                                                    | 2                            |
| 4.2 | Uniform Linear Arrays : Two-element arrays, N-element Broadside Array, and N-element End-Fire Array,.                                                                   | 2                            |
| 4.3 | Array Synthesis: Phased arrays and Beam steering and Grating lobes.                                                                                                     | 2                            |
| 4.4 | Non- Uniform Arrays: Introduction to Binomial Arrays and Tschebyscheff Arrays (Chebyshev).                                                                              | 2                            |
|     | <b>Module 5</b>                                                                                                                                                         | <b>8</b>                     |
| 5.1 | Ground Wave Propagation: Surface waves and Earth's curvature and tilt effects.                                                                                          | 2                            |

|     |                                                                                                          |                 |
|-----|----------------------------------------------------------------------------------------------------------|-----------------|
| 5.2 | Space Wave Propagation: LOS, Field strength calculations, Duct propagation, and Tropospheric scattering. | 2               |
| 5.3 | Sky Wave Propagation: Ionosphere structure and Virtual Height.                                           | 2               |
| 5.4 | Critical Frequency, Maximum Usable Frequency(MUF), and Skip Distance calculations                        | 2               |
|     | <b>Total Hours</b>                                                                                       | <b>40 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Mechanism Analysis: Explain the concept of "Retarded Potentials" and describe how a time-varying current lead to the radiation of electromagnetic waves.
2. Parameter Relation: An antenna has a radiation resistance of  $72\Omega$  and a loss resistance of  $8\Omega$ . If the directive gain is 15 dB, calculate the power gain and the radiation efficiency.
3. Link Budget: Two identical antennas are separated by a distance of 10 km and operate at 2 GHz. If the transmitter sends 20W of power and the received power is measured at 2uW, calculate the gain of the antennas (assume matched polarization).

#### Course Outcome 2 (CO 2):

1. Field Derivation: Starting from the vector potential, derive the far-field expressions ( $E_\theta$  and  $H_\phi$ ) for an infinitesimal (Hertzian) dipole.
2. Numerical Application: A thin dipole antenna is  $\lambda/15$  long. Calculate its radiation resistance and compare it with the standard  $73\Omega$  resistance of a half-wave dipole.
3. Image Theory: A vertical monopole antenna of height  $h = \lambda/4$  is mounted on a perfectly conducting ground plane. Use Image Theory to sketch the equivalent system and explain why the radiation resistance is half that of a center-fed  $\lambda/2$  dipole.

#### Course Outcome 3 (CO 3):

1. Reflector Systems: Explain the geometry and operational advantages of a Cassegrain Feed parabolic reflector compared to a prime-focus feed.

2. Patch Antenna Design: Discuss the physical factors that determine the resonant frequency of a rectangular microstrip patch antenna. Why is a high-dielectric substrate usually avoided for high-efficiency patch antennas?
3. Broadband Behavior: Describe how the geometry of a Log-Periodic Antenna allows it to maintain constant impedance and radiation characteristics over a very wide frequency range.

**Course Outcome 4 (CO 4):**

1. Array Synthesis: Design a 4-element Uniform Linear Array (ULA) with a spacing of  $d = \lambda/2$ . Find the required progressive phase shift ( $\alpha$ ) to make the array:(a) A Broadside Array.(b) An End-fire Array.
2. Pattern Multiplication: Using the principle of pattern multiplication, sketch the radiation pattern of an array consisting of two half-wave dipoles separated by  $\lambda/2$  and fed in phase.
3. Side-Lobe Level (SLL) Analysis: Compare the beamwidth and sidelobe levels of a 5-element Binomial Array with a 5-element Uniform Array. Why is the Binomial array often called a "non-sidelobe" array?

**Course Outcome 5 (CO 5):**

1. Sky Wave Propagation: The critical frequency of the F2 layer of the ionosphere is 10 MHz. If a radio wave is incident at an angle of  $60^\circ$  to the normal, calculate the Maximum Usable Frequency (MUF).
2. Range Calculation: A television transmitter antenna is 150m high and the receiving antenna is 20m high. Calculate the Line-of-Sight (LOS) distance and the maximum distance at which the signal can be intercepted, accounting for the  $4/3$  earth radius factor.
3. Atmospheric Effects: Explain the phenomenon of Tropospheric Ducting. Under what atmospheric conditions (temperature and humidity gradients) does duct propagation occur?

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2028**

**Course Code: B24EC4P53**

**Course Name: RADIATION AND PROPAGATION**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define Radiation Intensity and explain its relation to the power radiated by an antenna.
2. State the Friis Transmission Equation and its significance in wireless links.
3. What is meant by the "Image Theory" in monopole antennas?
4. Compare the radiation characteristics of a small loop antenna with a short dipole.
5. Briefly explain Huygens' Principle as applied to aperture antennas.
6. Mention the advantages of a Cassegrain feed mechanism in parabolic reflectors.
7. State the Principle of Pattern Multiplication for an antenna array.
8. What are grating lobes, and how can they be avoided in phased arrays?.
9. Distinguish between Critical Frequency and Maximum Usable Frequency (MUF).
10. Define "Skip Distance" in sky wave propagation.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) (a) Derive the expression for the far-field components of an oscillating Hertzian dipole. (10)  
b) Calculate the radiation resistance of a Hertzian dipole if its length is  $\lambda/50$ . (4)
12. a) Explain the terms: (i) Half Power Beamwidth (HPBW), (ii) Directivity, and (iii) Effective Aperture Area. (9)  
b) Describe the different types of antenna polarization. (5)

**Module II**

13. a) Derive the expression for the radiation resistance of a half-wave dipole antenna. (10)  
b) Explain the current distribution on a thin linear wire antenna of length  $L = \lambda/2$ . (4)
14. a) Analyze the field equations for a short dipole in the far-field region. (8)  
b) Discuss the effects of grounding on the radiation pattern of a monopole antenna. (6)

**Module III**

15. a) Describe the construction and operational principles of E-plane and H-plane horn antennas. (8)  
b) Discuss the basic characteristics and feeding methods of Rectangular Microstrip Patch Antennas. (6)
16. a) Explain the working of a Helical antenna in both Normal and Axial modes. (8)  
b) Write a short note on Log-Periodic antennas and their broadband applications. (6)

**Module IV**

17. a) Derive the array factor for an  $N$ -element Uniform Linear Array (ULA) and find the conditions for Broadside radiation.. (10)  
b) Explain the concept of beam steering in phased arrays. (4)
18. a) Discuss the synthesis of non-uniform arrays using the Binomial distribution method (8)  
b) Compare the performance of Broadside and End-Fire arrays. (6)

**Module V**

19. a) Explain the structure of the Ionosphere and discuss how it facilitates Sky Wave propagation. (8)  
b) Derive the expression for the Line-of-Sight (LOS) distance for space wave propagation. (6)
20. a) Define Virtual Height and derive the expression for MUF in terms of critical frequency and angle of incidence. (8)  
b) Explain the phenomenon of Duct Propagation and Tropospheric Scattering. (6)



| B24EC4P54 | OPTIMIZATION TECHNIQUES | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|-------------------------|---|---|---|---|--------|----------------------|
|           |                         | 2 | 1 | 0 | 4 | 3      | 2024                 |

**Preamble**

This course aims to provide a broad picture of various applications of optimization methods used in engineering.

**Prerequisites**

NIL

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                       |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Explain the fundamental concepts of engineering optimization and apply them to formulate engineering problems as mathematical programming models. [Understand, Apply] |
| <b>CO 2</b> | Apply classical optimization methods to solve problems. [Apply]                                                                                                       |
| <b>CO 3</b> | Solve linear programming problems using graphical and simplex methods. [Apply]                                                                                        |
| <b>CO 4</b> | Apply game theory concepts and network optimization methods to solve problems. [Apply]                                                                                |
| <b>CO 5</b> | Explain the basic concepts and framework of Genetic Algorithms and apply GA operators and fuzzy logic to solve optimization problems. [Understand, Apply]             |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 3    | 2    |      |      |      |      |      |      |       | 1     |
| <b>CO 2</b> | 3    | 3    |      | 2    | 2    |      |      |      |      |       | 1     |
| <b>CO 3</b> | 3    | 3    |      | 2    | 2    |      |      |      |      |       | 1     |
| <b>CO 4</b> | 3    | 3    | 2    | 2    | 2    |      |      |      |      |       | 1     |
| <b>CO 5</b> | 2    | 2    | 2    | 2    | 3    |      |      |      |      |       | 2     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 10                    | 10                 | 10                                    |
| Understand       | 20                    | 20                 | 20                                    |
| Apply            | 70                    | 70                 | 70                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Quiz/Course project         | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

#### Introduction to Engineering Optimization:

**Introduction:** Engineering applications of optimization, Formulation of design problems as mathematical programming problems, objective function, design variables and constraints.

**Classification of optimization problems:** Linear and nonlinear, constrained and unconstrained, Convex and non-convex optimization problems.

**Unconstrained single and multivariable optimisation:** necessary and sufficient conditions for optimality, Unimodal and multimodal functions.

### MODULE 2

#### Classical Optimization Methods:

**Multivariable constrained optimization:** Lagrange Multiplier method and KKT conditions.

**Single variable unconstrained optimization:** Newton Raphson method.

**Multi-variable unconstrained optimization:** Cauchy's (steepest descent) method.

### MODULE 3

**Linear programming problems:** Mathematical formulation of Linear Programming Problems (LPP), Slack, surplus and artificial variables, Reduction of LPP into the standard form, Solution using Simplex method and Graphical method, Optimality conditions and degeneracy, Duality in linear programming.

### MODULE 4

#### Game Theory and Network Optimization:

**Game Theory:** Introduction, 2- person zero sum game, Saddle point, Mini-Max and Maxi- Min Theorems (statement only), solution of 2x2 game, dominance property, Graphical solution (2x n, m x 2 game).

**Network optimization problems:** Introduction to network tree, Prim's Algorithm for minimal spanning tree, Shortest path problem using Dijkstra's Algorithm.

## MODULE 5

**Modern methods of optimization:** Introduction to Genetic algorithm, Basic GA framework. GA operators: Encoding, Crossover, Selection, Mutation. Introduction to Fuzzy logic, Fuzzy sets and membership functions, Operations on Fuzzy sets, Optimization of Fuzzy Systems.

### Text Books

1. S. S. Rao, Engineering Optimization: Theory and Practice, 5th Ed., Wiley, 2019.
2. H.A. Taha, “ Operations Research”, 5/e, Macmillan Publishing Company, 1992. Kanti Swarup, P.K.Gupta and Man Mohan, Operations Research, Sultan Chand and Sons.
3. Kalynamoy Deb. “Optimization for Engineering Design- Algorithms and Examples”, Prentice-Hall of India Pvt. Ltd., New Delhi.
4. A. Ravindran, D. T. Phillips, J. J. Solberg, Operations Research – Principles and Practice, John Wiley and Sons.
5. Kalavathy, S., Operations Research, 4th Edition, Vikas Publishing House Pvt. Ltd., New Delhi, 2013.
6. Ashok D Belegundu, Tirupathi R Chandrupatla, “Optimization concepts and Application in Engineering”, Pearson Education.
7. Hadley, G. “Linear programming”, Narosa Publishing House, New Delhi 5. J. S. Arora, Introduction to Optimum Design, McGraw-Hill Book Company.

### Simulation Assignments:

Atleast one assignment should be simulation of optimization Problems using MATLAB/ Scilab/ Python. The following simulations

1. Find the solution of the linear programming problem using simplex method.

$$\text{Minimize } f = -x_1 - 2x_2 - x_3$$

subject to

$$2x_1 + x_2 - x_3 \leq 2$$

$$2x_1 - x_2 + 5x_3 \leq 6$$

Refer MATLAB Solution of LP Problems SS Rao.

2. Create a weighted graph representing a 6-node communication network.
  - a) Implement Dijkstra’s Algorithm to find the shortest path between a source node and all other nodes.
  - b) Implement Prim’s Algorithm to find the Minimal Spanning Tree (MST) of the same network.

## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                      | No of Lecture/Tutorial Hours |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                            | <b>7</b>                     |
| 1.1 | Introduction: Engineering applications of optimization, Formulation of design problems as mathematical programming problems.                               | 1                            |
| 1.2 | Objective function, design variables and constraints.                                                                                                      | 1                            |
| 1.3 | Classification of optimization problems: linear and nonlinear, constrained and unconstrained.                                                              | 1                            |
| 1.4 | Convex and non-convex optimization problems.                                                                                                               | 2                            |
| 1.5 | Unconstrained single and multivariable optimisation- necessary and sufficient conditions for optimality. Unimodal and multimodal functions.                | 2                            |
|     | <b>Module 2</b>                                                                                                                                            | <b>7</b>                     |
| 2.1 | Multivariable constrained optimization- Lagrange Multiplier method and KKT conditions..                                                                    | 3                            |
| 2.2 | Single variable unconstrained optimization- Newton Raphson method.                                                                                         | 2                            |
| 2.3 | Multi-variable unconstrained optimization- Cauchy's (steepest descent) method.                                                                             | 2                            |
|     | <b>Module 3</b>                                                                                                                                            | <b>7</b>                     |
| 3.1 | Mathematical formulation of Linear Programming Problems (LPP), Slack, surplus and artificial variables.                                                    | 1                            |
| 3.2 | Reduction of LPP into the standard form.                                                                                                                   | 1                            |
| 3.3 | Solution using Simplex method and Graphical method.                                                                                                        | 4                            |
| 3.4 | Optimality conditions and degeneracy, Duality in linear programming.                                                                                       | 1                            |
|     | <b>Module 4</b>                                                                                                                                            | <b>7</b>                     |
| 4.1 | Introduction, 2- person zero sum game, Saddle point, Mini-Max and Maxi- Min Theorems (statement only).                                                     | 1                            |
| 4.2 | Solution of 2x2 game, dominance property.                                                                                                                  | 2                            |
| 4.3 | Graphical solution (2x n, m x 2 game).                                                                                                                     | 2                            |
| 4.4 | Network optimization problems: Introduction to network tree, Prim's Algorithm for minimal spanning tree, Shortest path problem using Dijkstra's Algorithm. | 2                            |
|     | <b>Module 5</b>                                                                                                                                            | <b>7</b>                     |
| 5.1 | Introduction to Genetic algorithm, Basic GA framework.                                                                                                     | 1                            |
| 5.2 | GA operators: Encoding, Crossover, Selection, Mutation.                                                                                                    | 2                            |
| 5.3 | Introduction to Fuzzy logic, Fuzzy sets and membership functions.                                                                                          | 2                            |
| 5.4 | Operations on Fuzzy sets, Optimization of Fuzzy Systems..                                                                                                  | 2                            |
|     | <b>Total Hours</b>                                                                                                                                         | <b>35 Hours</b>              |

## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1):**

1. Understand the different classification of optimization problems
2. Apply basic concepts of mathematics to formulate an optimization problem.
3. Identify extreme points of a given function and classify as minimum, maximum or saddle point.

### **Course Outcome 2 (CO 2):**

1. Formulate Lagrangian equation for constrained problems and solution using KKT conditions.
2. Apply newton raphson method to find the optimal solution.
3. Find optimal point of a given function using gradient methods.

### **Course Outcome 3 (CO 3):**

1. Formulation of real world problems as linear programming problems.
2. Find optimum solution using Simplex method for the given problem.
3. Find optimum solution using graphical method for the given problem.

### **Course Outcome 4 (CO 4):**

1. Evaluate the strategies to be adopted for players using game theory.
2. Using algorithms find minimum spanning tree and shortest distance for given network path.
3. Two identical sections of the given networks are connected in parallel. Obtain the two port network parameters of the combination.

### **Course Outcome 5 (CO 5):**

1. Explain different steps in the genetic algorithm.
2. List the basic steps in a GA framework.
3. Define mutation in genetic algorithms.



MODEL QUESTION PAPER

QP CODE:

Pages: 5

Reg.No.: .....

Name: .....

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2028

Course Code: B24EC4P54

Course Name: OPTIMIZATION TECHNIQUES

Max. Marks: 100

Duration: 3 hours

**PART A**

*Answer all questions. Each question carries 3 marks*

1. Give five typical applications of optimization techniques in engineering discipline.
2. What are the necessary and sufficient conditions for the relative minimum of a function of a single variable?
3. What is the significance of gradient function in minimization problem?
4. Explain the concept of Fibonacci optimization method.
5. Explain the transformations needed to represent an LPP in standard form.
6. State the duality principle and write the dual of the following LPP.

Minimize  $Z = 24x_1 + 30x_2$  subject to

$$2x_1 + 3x_2 \geq 10, 4x_1 + 9x_2 \geq 15, 6x_1 + 6x_2 \geq 20, x_1, x_2 \geq 0$$

7. State dominance property in game theory.
8. Write a short note on Dijkstra's shortest path algorithm.
9. Discuss membership function in fuzzy logic.
10. Name and describe the main five features of Genetic Algorithm.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Maximize  $f(x) = 2x_1 + x_2 + 10$  subject to  $x_1 + 2x_2 - 3 = 0$  (7)

- b) Find the extreme points of the function:  
 $f(x_1, x_2, x_3) = x_1 + 2x_3 + x_2x_3 - x_1^2 - x_2^2 - x_3^2$  (7)

12. a) Determine whether the following matrix is positive or negative definite.

$$A = \begin{pmatrix} 3 & 1 & -1 \\ 1 & 3 & -1 \\ -1 & -1 & 5 \end{pmatrix}$$

(7)

- b) Find the extreme points of the function  $f(x_1, x_2) = x_1^3 + x_2^3 + 2x_1^2 + 4x_2^2 + 6$ . (7)

**Module II**

13. a) Apply Lagrangian method to find minimum of the constrained problem

$$f(x_1, x_2) = x_1^2 + x_2^2, \text{ subject to } g(x) = 5x_1 + 6x_2 - 30 = 0.$$

(7)

- b) Using KKT Method, maximize  $U = xy$  subject to

$$x + y \leq 50, \quad 2x + y \leq 60$$

(7)

14. a) Using Newton's Raphson method, find the maximum of  $f(x) = 2 \sin x - \frac{x^2}{10}$  with an initial guess of  $x_0 = 2.5$ . (14)

**Module III**

15. a) Solve the following LPP graphically: Maximise  $z = 3x_1 + 2x_2$  subject to : (10)

$$x_1 + x_2 \leq 80, \quad 2x_1 + x_2 \leq 100, \quad x_1 \leq 40, \quad x_1 \geq 0, \quad x_2 \geq 0.$$

- b) Explain degeneracy in simplex method. (4)

16. Solve the following LPP using the simplex method: Maximize  $z = 5x_1 + 4x_2$ , subject to : (14)

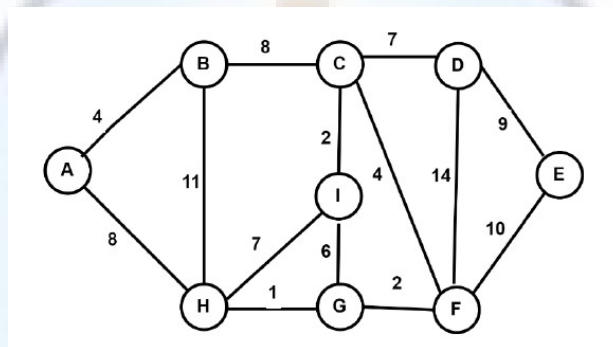
$$6x_1 + 4x_2 \leq 24, \quad x_1 + 2x_2 \leq 6, \quad -x_1 + x_2 \leq 1, \quad x_2 \leq 2, \quad x_1 \geq 0, \quad x_2 \geq 0.$$

**Module IV**

17. The payoff matrix of Player A is given in the table. Solve to obtain the optimal strategy using graphical method. (14)

$$\begin{bmatrix} 1 & -3 \\ 3 & 5 \\ -1 & 6 \\ 4 & 1 \\ 2 & 2 \\ -5 & 0 \end{bmatrix}$$

18. Find the minimum spanning tree using Prim's algorithm. (14)



### Module V

19. Consider membership functions of two fuzzy sets  $\tilde{A}$  and  $\tilde{B}$  given by  $\mu_A(x) = \frac{x}{x+2}$  and  $\mu_B(x) = 3^{-x}$ . Find the membership functions of:

- $\tilde{A}^c$
- $\tilde{B}^c$
- $\tilde{A} \cup \tilde{B}$
- $\tilde{A} \cap \tilde{B}$
- $(\tilde{A} \cup \tilde{B})^c$ . where,  $^c$  is complement.

(14)

20. a) Consider the fuzzy relation R defined in A X A. Check whether the fuzzy relation is i) Reflexive, ii) Symmetric and iii) Transitive.

$$R = \begin{bmatrix} 0.4 & 0.1 & 0.7 \\ 0.1 & 0.2 & 0.2 \\ 0.4 & 0.5 & 0.3 \end{bmatrix}$$

(7)

- b) Explain the working principles of Genetic Algorithms.

(7)

| B24EC4P55 | ERROR<br>CONTROL<br>CODES | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|---------------------------|---|---|---|---|--------|-------------------------|
|           |                           | 2 | 1 | 0 | 4 |        |                         |

**Preamble**

This course aims to give an insight into the various codes used for error control in data transmission.

**Prerequisites**

B24EC4T01 : INFORMATION THEORY AND CODING

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                                     |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the principles of block codes, types and their bounds [Understand, Apply]                                                                                                |
| <b>CO 2</b> | Understand the principles of cyclic codes and Galois Fields, encoding and decoding of binary BCH codes and algorithms for finding the error location polynomial [Understand, Apply] |
| <b>CO 3</b> | Demonstrate encoding, decoding and error location of Reed Solomon codes and Reed Muller codes [Understand, Apply]                                                                   |
| <b>CO 4</b> | Illustrate the encoding and decoding of Convolution Codes and Turbo Codes. [Understand, Apply]                                                                                      |
| <b>CO 5</b> | Describe the encoding, decoding and applications of LDPC Codes. Discuss the concepts of polar codes and its applications in 5G [Understand, Apply]                                  |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 3    | 2    | 1    |      | 2    |      |      |      |       | 2     |
| <b>CO 2</b> | 3    | 3    | 2    | 1    |      | 2    |      |      |      |       | 2     |
| <b>CO 3</b> | 3    | 3    | 2    | 1    |      | 2    |      |      |      |       | 2     |
| <b>CO 4</b> | 3    | 3    | 2    | 1    |      | 2    |      |      |      |       | 2     |
| <b>CO 5</b> | 3    | 3    | 2    | 1    |      | 2    |      |      |      |       | 2     |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 40                    | 40              | 40                                 |
| Apply            | 40                    | 40              | 40                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Block Codes and Bounds:** Error Control Coding – Relevance of error control codes in Communication System, concepts of Code rate, Hamming Distance, Minimum Distance, Error detecting and correcting capability. Repetition Codes, Hamming Codes, Review of Groups, Fields, Vector Spaces. Linear Block Codes - Generator matrix, Parity Check Matrix. Dual Codes, Error Detection and Correction over hard output channels. Dual of binary Hamming codes. Maximum Likelihood Decoding Simple bounds on block codes - Singleton bound, Hamming Bound, Gilbert-Varshamov bound. Maximum-distance-separable (MDS) codes.

### MODULE 2

**Cyclic Codes:** Review of basic concepts of cyclic codes – generator matrix, parity-check matrix. Polynomial view point. Encoding, systematic encoding, syndrome decoding. Galois Fields – Irreducible and Primitive Polynomials, Primitive elements, Field extension, Conjugate elements and Minimal Polynomials. BCH Codes - Design, BCH Bound, Decoding BCH codes – Decoding BCH – the general outline, computation of the syndrome, Chien Search algorithm, Finding the error locator polynomial. Berlekamp Massey Algorithm. Burst-error correction capability of BCH codes

### MODULE 3

**Reed-Solomon and Reed-Muller Codes:** Reed Solomon Codes – BCH code viewpoint. Vandermonde matrix view point. MDS property. Generalized Reed-Solomon codes. Application of BCH decoding algorithms to Reed-Solomon decoding. Sudan's algorithm for decoding. Use of RS codes in disks and cloud storage. Reed Muller Codes, Encoding and decoding of RM (1, m) codes. Majority-logic decoding of Reed-Muller codes.

### MODULE 4

**Convolutional and Turbo Codes:** Convolution Codes, State Diagram, Systematic Encoders, Decoding of Convolution Codes – Viterbi algorithm, Turbo Codes, Encoding parallel concatenated codes.

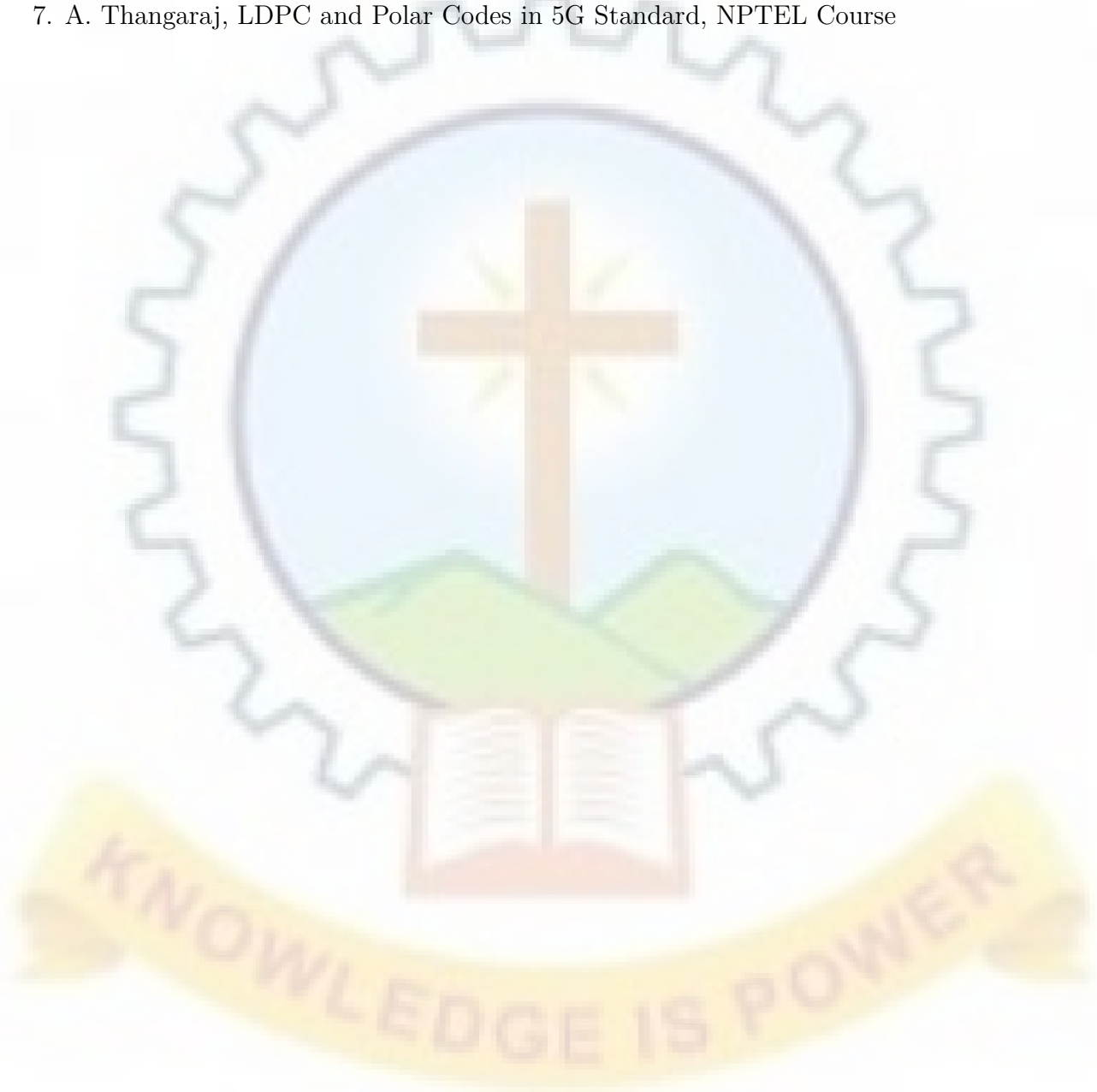
### MODULE 5

**LDPC and Polar Codes:** Low Density Parity Codes, Construction, Tanner Graphs, Message passing decoding. Example of message passing decoding over binary erasure channels. Message passing of LLR and decoding over AWGN channels. Polar Codes – Introduction, polarization of BEC channels, Polar transform and frozen bits. LDPC and Polar codes in 5G.



**Text Books**

1. Shu Lin, D. J Costello Jr. Error Control Coding: Fundaments and Applications, Prentice Hall
2. Ron M Roth, Introduction to Coding Theory, Cambridge University Press
3. Todd K. Moon, Error Correction Coding: Mathematical Methods and Algorithms, Wiley.
4. . T. Richardson, R. Urbanke, Modern Coding Theory, Cambridge University Press
5. H. Pfister, A Brief Introduction to Polar Codes, Lec. Notes.
6. O. Gazi, Polar Codes: A Non-Trivial Approach to Channel Coding, Springer, 2018
7. A. Thangaraj, LDPC and Polar Codes in 5G Standard, NPTEL Course



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                                                                                                                                  | No of Lecture/Tutorial Hours |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                                                                                                                                        | <b>7</b>                     |
| 1.1 | Block Codes and Bounds. Error Control Coding – Relevance of error control codes in Communication System, concepts of Code rate, Hamming Distance, Minimum Distance, Error detecting and correcting capability.                                                         | 2                            |
| 1.2 | Repetition Codes, Hamming Codes, Review of Groups, Fields, Vector Spaces. Linear Block Codes - Generator matrix, Parity Check Matrix. Dual Codes, Error Detection and Correction over hard output channels. Dual of binary Hamming codes. Maximum Likelihood Decoding. | 3                            |
| 1.3 | Simple bounds on block codes - Singleton bound, Hamming Bound, Gilbert-Varshamov bound. Maximum-distance-separable (MDS) codes.                                                                                                                                        | 2                            |
|     | <b>Module 2</b>                                                                                                                                                                                                                                                        | <b>8</b>                     |
| 2.1 | Review of basic concepts of cyclic codes – generator matrix, parity-check matrix. Polynomial view point. Encoding, systematic encoding, syndrome decoding.                                                                                                             | 2                            |
| 2.2 | Galois Fields – Irreducible and Primitive Polynomials, Primitive elements, Field extension, Conjugate elements and Minimal Polynomials.                                                                                                                                | 2                            |
| 2.3 | BCH Codes - Design, BCH Bound, Decoding BCH codes – Decoding BCH – the general outline, computation of the syndrome, error locator polynomial .                                                                                                                        | 2                            |
| 2.4 | Chien Search algorithm, Finding the error locator polynomial. Berlekamp Massey Algorithm. Burst-error correction capability of BCH codes.                                                                                                                              | 2                            |
|     | <b>Module 3</b>                                                                                                                                                                                                                                                        | <b>7</b>                     |
| 3.1 | Reed Solomon Codes – BCH code viewpoint. Vandermonde matrix view point. MDS property. Generalized Reed-Solomon codes. Application of BCH decoding algorithms to Reed-Solomon decoding.                                                                                 | 3                            |
| 3.2 | Sudan's algorithm for decoding. Use of RS codes in disks and cloud storage.                                                                                                                                                                                            | 2                            |
| 3.2 | Reed Muller Codes, Encoding and decoding of RM (1, m) codes. Majority-logic decoding of Reed-Muller codes.                                                                                                                                                             | 2                            |
|     | <b>Module 4</b>                                                                                                                                                                                                                                                        | <b>6</b>                     |
| 4.1 | Convolution Codes, State Diagram, Systematic Encoders, Decoding of Convolution Codes – Viterbi algorithm.                                                                                                                                                              | 3                            |
| 4.2 | Turbo Codes, Encoding parallel concatenated codes.                                                                                                                                                                                                                     | 3                            |
|     | <b>Module 5</b>                                                                                                                                                                                                                                                        | <b>7</b>                     |

|     |                                                                                                                                                                                                           |                 |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 5.1 | Low Density Parity Codes, Construction, Tanner Graphs, Message passing decoding. Example of message passing decoding over binary erasure channels. Message passing of LLR and decoding over AWGN channels | 4               |
| 5.2 | Polar Codes – Introduction, polarization of BEC channels, Polar transform and frozen bits. LDPC and Polar codes in 5G.                                                                                    | 3               |
|     | <b>Total Hours</b>                                                                                                                                                                                        | <b>35 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Define Code Rate, Hamming Distance and Error detection and correction capabilities of Block codes
2. Construct Hamming Codes for a given Generator Matrix
3. State and prove Gilbert Varshamov bound.

#### Course Outcome 2 (CO 2):

1. Design a  $(n,k)$  cyclic code in systematic form using a given generator polynomial  $g(X)$
2. Determine all the conjugacy classes in an extended GF with respect to a give GF
3. Describe the Chein search algorithm for finding the error locator polynomial for Binary BCH Codes

#### Course Outcome 3 (CO 3):

1. Differentiate between the BCH and Vandermonde viewpoints of Reed Solomon Codes
2. Explain Sudan's algorithm for decoding RS codes
3. Design an encoding circuit for RM  $(1, m)$  code

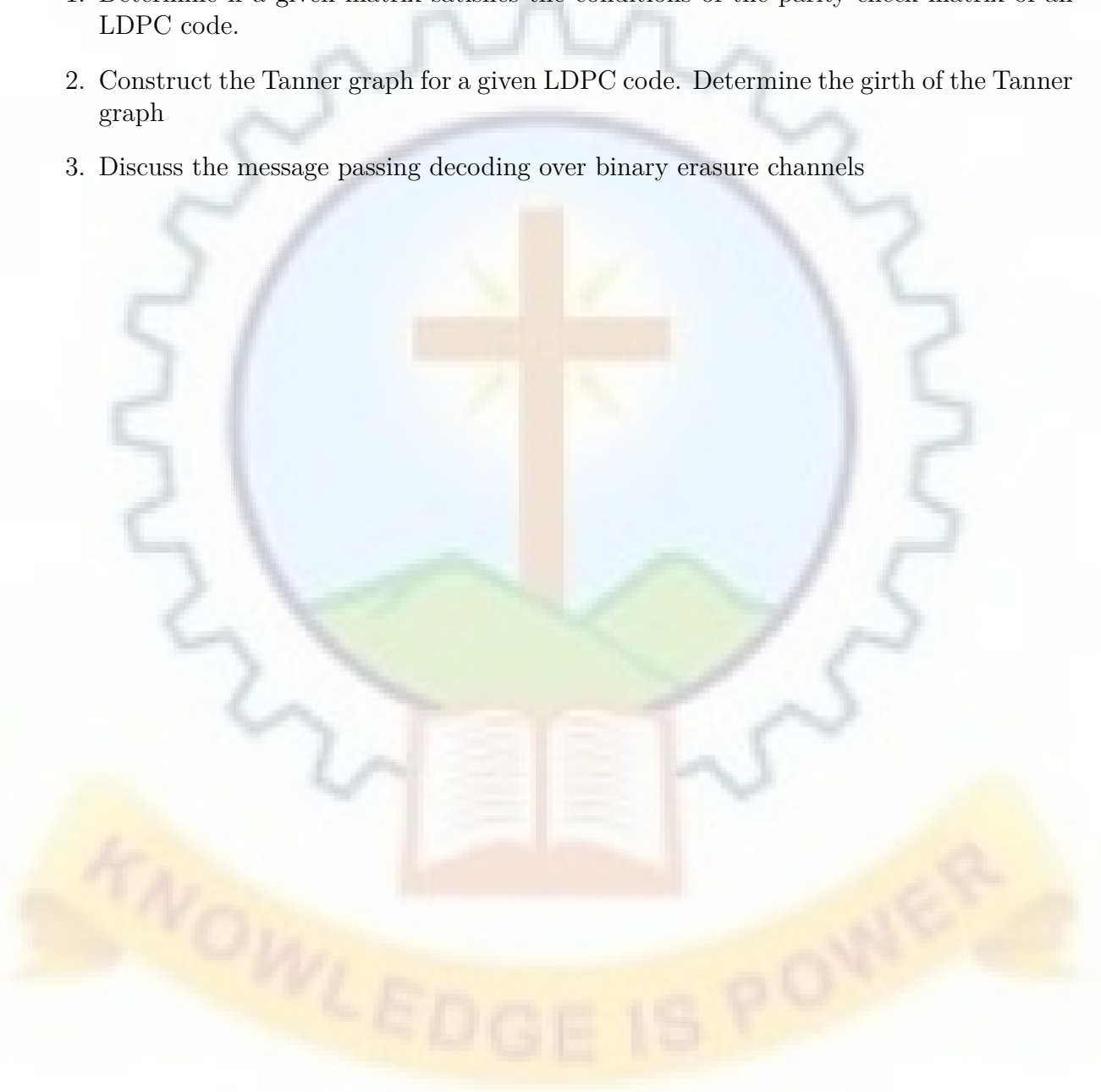
#### Course Outcome 4 (CO 4):

1. Construct an encoder, state diagram and trellis for a convolution encoder using a given generator polynomial..

2. Decode convolution codes using Viterbi decoder
3. Construct a Turbo encoder for a given generator polynomial

**Course Outcome 5 (CO 5):**

1. Determine if a given matrix satisfies the conditions of the parity check matrix of an LDPC code.
2. Construct the Tanner graph for a given LDPC code. Determine the girth of the Tanner graph
3. Discuss the message passing decoding over binary erasure channels



MODEL QUESTION PAPER

QP CODE:

Pages: 5

Reg.No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2028

Course Code: B24EC4P55

**ERROR CONTROL CODES**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Generate all the code polynomials for the (7,4) Hamming Code generator polynomial  $g(x) = 1+x+x^3$
2. Define (a) MDS Code (b) Minimum Distance (c) Repetition Code.
3. Determine if  $x^5+x^3+1$  is irreducible over GF (2)
4. Illustrate the general outline for decoding BCH codes
5. Prove that the minimum distance of an (n,k) RS code is  $n-k+1$
6. Construct the Generator matrix of a RM(1,3) code
7. Describe a catastrophic encoder
8. Discuss the applications of turbo codes in 5G
9. Explain the method of construction of LDPC Codes
10. Describe the applications of polar codes in 5G

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Define and prove Hamming bound and Gilbert Varshamov bounds. (7)  
b) For the (7,4) Hamming code generator polynomial  $g(x) = 1+x+x^3$ , generate all possible code polynomials  $c(x)$ . Determine the parity check matrix  $h(x)$  for this code. Calculate the minimum distance of the Hamming code generated (7)
12. Consider a systematic block code whose parity check equations are:  
 $p_1 = m_1+m_2+m_4$   $p_2 = m_1+m_3+m_4$   $p_3 = m_1+m_2+m_3$   $p_4 = m_2+m_3+m_4$  where  $m_i$  are the message digits and  $p_i$  are the check digits
- a) Find the generator matrix and parity check matrix for this code  
b) How many errors can the code correct?  
c) Is the vector 10101010 a code word? (14)

**Module II**

13. a) For a binary, narrow sense, triple error correcting BCH code of length 15, constructed using the polynomial  $x^4+x+1$   
a) Compute a generator polynomial for this code  
b) Determine the rate of the code  
c) Construct the parity check matrix and generator matrix for this code. (7)  
b) Define and prove the BCH bound. (7)
14. a) Construct the systematic encoder for cyclic codes and explain its working. (7)  
b) Describe the Chien search algorithm for BCH codes. (7)

**Module III**

15. a) Explain Sudan's algorithm for Reed Solomon Codes. (7)  
b) Differentiate between the BCH Viewpoint and Vandermonde viewpoints of Reed Solomon Codes. (7)
16. (a) Form the generator matrix of the first order RM code RM (1,3) of length 8. What is the minimum distance of the code? Determine its parity check sums and devise a majority logic decoder for the code. Decode the received vector  $r = (01000101)$  (14)

**Module IV**

17. For the  $R=1/2$  convolution encoder with  $G(x) = [1+x^2+x^3 \ 1+x+x^3]$   
(a) Draw a hardware realization of the encoder  
(b) Determine the convolution generator matrix  $G$   
(c) For the input sequence  $m = [1,0,1,1,0,1,1]$  determine the coded output sequence  
(d) Draw the state diagram  
(e) Draw the trellis



- (f) Is this a catastrophic realization? Justify your answer. (14)
18. a) Illustrate Turbo encoding without and with puncturing (7)
- b) Explain the Viterbi algorithm and the schematic of add compare select hardware implementation. (7)

**Module V**

19. (a) For the parity check matrix

$$\begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 & 1 \end{bmatrix}$$

- a) Construct the Tanner graph for the code
- b) Determine the girth of the minimum girth cycle
- c) Determine the number of cycles of length 6
- d) Determine a generator matrix for this code

(14)

**Module V**

20. a) Describe the basic ideas of polarization (7)
- b) Explain channel polarization for N=2 channel (7)

| B24EC4P61 | DATA ANALYTICS | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|----------------|---|---|---|---|--------|----------------------|
|           |                | 2 | 1 | 0 | 4 | 3      | 2024                 |

### Preamble

This course helps to understand the basic concepts of data analytics. This course covers mathematics for data analytics, predictive and descriptive analytics of data, Big data and its applications, techniques for managing big data and data analysis & visualization using R programming tool. It enables the learners to perform data analysis on a real world scenario using appropriate tools.

### Prerequisites

NIL

### Course Outcomes

After the completion of the course, the student will be able to:

|             |                                                                                                                      |
|-------------|----------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Apply statistical and probability concepts to analyze data and perform hypothesis testing. [Apply, Analyze]          |
| <b>CO 2</b> | Understand the data analytics process and apply data collection and preprocessing techniques. [Understand, Apply]    |
| <b>CO 3</b> | Apply supervised and unsupervised learning algorithms for predictive and descriptive data analysis. [Apply–Analyze]. |
| <b>CO 4</b> | Apply big data analytics concepts and MapReduce techniques to solve large-scale data problems. [Apply]               |
| <b>CO 5</b> | Use R programming to perform exploratory data analysis, visualization, and statistical evaluation. [ Apply]          |

### Mapping of Course Outcomes With Program Outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 2    |      | 3    | 2    |      |      |      |      |       | 1     |
| <b>CO 2</b> | 2    | 2    |      | 3    | 2    |      |      |      |      |       | 2     |
| <b>CO 3</b> | 2    | 3    | 2    | 3    | 2    |      |      |      |      |       | 1     |
| <b>CO 4</b> | 2    | 2    | 3    | 3    | 2    |      |      |      |      |       | 2     |
| <b>CO 5</b> | 2    | 2    | 2    | 3    | 2    |      |      |      |      |       | 3     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 10                    | 10                 | 10                                    |
| Understand       | 20                    | 20                 | 20                                    |
| Apply            | 50                    | 50                 | 50                                    |
| Analyse          | 20                    | 20                 | 20                                    |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Mathematics for Data Analytics:** Descriptive statistics - Measures of central tendency and dispersion, Association of two variables -Discrete variables, Ordinal and Continuous variable, Probability calculus - probability distributions, Inductive statistics - Point estimation, Interval estimation, Hypothesis Testing - Basic definitions, t-test

### MODULE 2

**Introduction to Data Analytics:** Introduction to Data Analysis - Analytics, Analytics Process Model, Analytical Model Requirements. Data Analytics Life Cycle overview. Basics of data collection, sampling, preprocessing and dimensionality reduction

### MODULE 3

**Predictive and Descriptive Analytics:** Supervised Learning - Classification, Naive Bayes, KNN, Linear Regression. Unsupervised Learning - Clustering, Hierarchical algorithms – Agglomerative algorithm, Partitional algorithms -K- Means. Association Rule Mining - Apriori algorithm

### MODULE 4

**Big Data Analytics:** Big Data Overview – State of the practice in analytics, Example Applications - Credit Risk Modeling, Business Process Analytics. Big Data Analytics using Map Reduce and Apache Hadoop, Developing and Executing a HadoopMapReduce Program..

### MODULE 5

**R programming for Data Analysis:** Overview of modern data analytic tools. Data Analysis Using R - Introduction to R - R Graphical User Interfaces, Data Import and Export, Attribute and Data Types, Descriptive Statistics, Exploratory Data Analysis - Visualization Before Analysis, Dirty Data, Visualizing a Single Variable, Examining Multiple Variables, Data Exploration Versus Presentation, Statistical Methods for Evaluation

### Text Books

1. Bart Baesens, " Analytics in a Big Data World: The Essential Guide to Data Science and its Business Intelligence and Analytic Trends", John Wiley & Sons, 2013.

2. David Dietrich, "EMC Education Services, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data", John Wiley & Sons, 2015.
3. Jaiwei Han, Micheline Kamber, "Data Mining Concepts and Techniques", Elsevier, 2006.
4. Christian Heumann and Michael Schomaker, "Introduction to Statistics and Data Analysis", Springer, 2016



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                | No of Lecture/Tutorial Hours |
|-----|----------------------------------------------------------------------|------------------------------|
|     | <b>Module 1:Mathematics for Data Analytics</b>                       | <b>10</b>                    |
| 1.1 | Descriptive statistics – Measures of central tendency and dispersion | 2                            |
| 1.2 | Association of two variables                                         | 1                            |
| 1.3 | Discrete, Ordinal and Continuous variables                           | 1                            |
| 1.4 | Probability calculus and probability distributions                   | 2                            |
| 1.5 | Inductive statistics – Point and interval estimation                 | 2                            |
| 1.6 | Hypothesis testing – Basic definitions and t-test                    | 2                            |
|     | <b>Module 2: Introduction to Data Analytics</b>                      | <b>9</b>                     |
| 2.1 | Introduction to Data Analysis and Analytics                          | 1                            |
| 2.2 | Analytics Process Model                                              | 1                            |
| 2.3 | Analytical Model Requirements                                        | 1                            |
| 2.4 | Data Analytics Life Cycle – Overview                                 | 2                            |
| 2.5 | Data collection and sampling                                         | 1                            |
| 2.6 | Data preprocessing                                                   | 2                            |
| 2.7 | Dimensionality reduction                                             | 1                            |
|     | <b>Module 3:Predictive and Descriptive Analytics</b>                 | <b>10</b>                    |
| 3.1 | Supervised learning – Classification concepts                        | 1                            |
| 3.2 | Naïve Bayes algorithm                                                | 2                            |
| 3.3 | K-Nearest Neighbour (KNN)                                            | 1                            |
| 3.4 | Linear Regression                                                    | 2                            |
| 3.5 | Unsupervised learning – Clustering concepts                          | 1                            |
| 3.6 | Hierarchical clustering – Agglomerative algorithm                    | 1                            |
| 3.7 | Partitional clustering – K-Means algorithm                           | 1                            |
| 3.8 | Association Rule Mining – Apriori algorithm                          | 1                            |
|     | <b>Module 4:Big Data Analytics</b>                                   | <b>8</b>                     |
| 4.1 | Big Data overview and state of practice in analytics                 | 1                            |
| 4.2 | Big Data applications – Credit Risk Modeling                         | 1                            |
| 4.3 | Business Process Analytics                                           | 1                            |
| 4.4 | Big Data Analytics using MapReduce                                   | 2                            |
| 4.5 | Apache Hadoop – Architecture and ecosystem                           | 1                            |
| 4.6 | Developing and executing a Hadoop MapReduce program                  | 2                            |
|     | <b>Module 5:R Programming for Data Analysis</b>                      | <b>8</b>                     |
| 5.1 | Overview of modern data analytics tools                              | 1                            |
| 5.2 | Introduction to R and R graphical user interfaces                    | 1                            |
| 5.3 | Data import and export in R                                          | 1                            |
| 5.4 | Attributes and data types in R                                       | 1                            |
| 5.5 | Descriptive statistics using R                                       | 1                            |
| 5.6 | Exploratory Data Analysis (EDA)                                      | 1                            |
| 5.7 | Data visualization ,Statistical methods for evaluation               | 2                            |



## CO ASSESSMENT QUESTIONS

### Course Outcome 1 (CO 1):

1. Compute and interpret measures of central tendency and dispersion for a given dataset. Explain the significance of each measure in data analysis.
2. Perform hypothesis testing using a *t-test* for a given problem. Explain the steps involved, assumptions made, and interpretation of results.

### Course Outcome 2 (CO 2):

1. Explain the Data Analytics Process Model and illustrate the Data Analytics Life Cycle with a neat diagram.
2. Discuss data collection, sampling, and preprocessing techniques used in data analytics. Explain the role of dimensionality reduction in improving analytical models.

### Course Outcome 3 (CO 3):

1. Apply Naïve Bayes and K-Nearest Neighbour (KNN) algorithms to a given dataset and compare their performance.
2. Perform clustering using the K-Means algorithm and explain the results obtained. Also, describe the working of the Apriori algorithm for association rule mining.

### Course Outcome 4 (CO 4):

1. Explain the concepts and characteristics of Big Data and discuss its applications in credit risk modeling and business process analytics.
2. Describe the Hadoop architecture and develop a simple MapReduce program to process large-scale data. Explain the execution flow.

### Course Outcome 5 (CO 5):

1. Write R commands to import a dataset and perform descriptive statistics and exploratory data analysis (EDA).
2. Visualize single and multiple variables using R and interpret the results. Explain how statistical methods are used for data evaluation.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027**

**Course Code: B24EC4P61**

**Course Name: DATA ANALYTICS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define descriptive statistics. List any two measures of dispersion.
2. Differentiate between discrete and continuous variables with examples.
3. State the null and alternative hypotheses.
4. What is data preprocessing? Mention any two preprocessing techniques.
5. Define supervised learning with one example.
6. What is K-Means clustering?
7. Define association rule mining. What is support?
8. List any three characteristics of Big Data.
9. What is MapReduce?
10. What is Exploratory Data Analysis (EDA)?

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain measures of central tendency and dispersion. Illustrate their use in data analysis with suitable examples. (14)
- b) Explain hypothesis testing in detail and perform a t-test for a given dataset. Interpret the results. (14)

**Module II**

12. a) Explain the Data Analytics Process Model and the Data Analytics Life Cycle with a neat diagram. (14)
- b) Discuss data collection, sampling, data preprocessing, and dimensionality reduction techniques used in data analytics. (14)

**Module III**

13. a) Explain the Naïve Bayes and K-Nearest Neighbour (KNN) algorithms with suitable examples. (14)
- b) Explain K-Means clustering and the Apriori algorithm. Discuss their applications in data analytics. (14)

**Module IV**

14. a) Explain the concepts, characteristics, and applications of Big Data with reference to credit risk modeling. (14)
- b) Explain data import, descriptive statistics, and data visualization techniques in R with examples. (14)

**Module V**

15. a) Explain data import, descriptive statistics, and data visualization techniques in R with examples. (14)
- b) Perform Exploratory Data Analysis (EDA) using R and explain how statistical methods are used for evaluation (14)

| B24EC4P62 | PATTERN<br>RECOGNITION | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|------------------------|---|---|---|---|--------|-------------------------|
|           |                        | 2 | 1 | 0 | 4 | 3      | 2024                    |

**Preamble**

The objective of this course is to equip students with the knowledge required to design and implement pattern recognition systems and to understand their applications in solving real-world problems. By the end of the course, students will be able to analyze datasets, apply appropriate pattern recognition techniques, and evaluate the performance of classification and clustering algorithms.

**Prerequisites**

Basic knowledge of Machine Learning, linear algebra, probability theory and statistics

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                                                                     |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the fundamental concepts of pattern recognition including pattern representation, learning approaches, decision boundaries, metric spaces, and distance measures.. [Understand]                          |
| <b>CO 2</b> | Apply different classification techniques such as decision trees, naïve Bayes, logistic regression, support vector machines, random forests, and K-nearest neighbour for pattern classification.[Understand, Apply] |
| <b>CO 3</b> | Understand and implement unsupervised learning and clustering techniques such as K-means and hierarchical clustering and evaluate clustering results. [Understand, Apply]                                           |
| <b>CO 4</b> | Apply feature extraction and feature selection methods using algorithms such as branch and bound, sequential forward/backward selection, and (l, r) algorithm. [Understand, Apply]                                  |
| <b>CO 5</b> | Understand recent advances in pattern recognition including structural pattern recognition, fuzzy classification, soft computing, neuro-fuzzy techniques, and density estimation methods. [Understand, Apply]       |

**Mapping of Course Outcomes With Program Outcomes**

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    | 1    |      |      |      |      |      |      |       |       |
| CO 2 | 3    | 3    | 2    | 1    |      |      |      |      |      |       |       |
| CO 3 | 2    | 3    | 2    | 2    | 2    |      |      |      |      |       |       |
| CO 4 | 2    | 3    | 3    | 2    | 2    |      |      |      |      |       |       |
| CO 5 | 2    | 2    | 1    | 1    | 2    |      |      |      |      |       |       |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Fundamentals of Pattern Recognition:** Introduction – Definitions, data sets for Pattern, Application Areas and Examples of pattern recognition, Design principles of pattern recognition system, Classification and clustering, supervised Learning, unsupervised learning and adaptation, Pattern recognition approaches, Decision Boundaries, Decision region, Metric spaces, distances.

### MODULE 2

**Classification Techniques in Pattern Recognition:** Classification: introduction, application of classification, types of classification, decision tree, naïve bayes, logistic regression, support vector machine, random forest, K Nearest Neighbour Classifier and variants, Efficient algorithms for nearest neighbour classification, Different Approaches to Prototype Selection, Combination of Classifiers, Training set, test set, standardization and normalization.

### MODULE 3

**Unsupervised Learning and Clustering Methods:** Different Paradigms of Pattern Recognition, Representations of Patterns and Classes, Unsupervised Learning & Clustering: Criterion functions for clustering, Clustering Techniques: Iterative square-error partitional clustering – K means, hierarchical clustering, Cluster validation.

### MODULE 4

**Feature Extraction and Feature Selection:** Introduction of feature extraction and feature selection, types of feature extraction, Problem statement and Uses, Algorithms - Branch and bound algorithm, sequential forward / backward selection algorithms, (l,r) algorithm.

### MODULE 5

**Techniques in Pattern Recognition:** Recent advances in Pattern Recognition, Structural PR, SVMs, FCM, Soft computing and Neuro-fuzzy techniques, and real-life examples, Histograms rules, Density Estimation, Nearest Neighbor Rule, Fuzzy classification.

### Text Books



1. Richard O. Duda, Peter E. Hart and David G. Stork, “Pattern Classification”, 2nd Edition, John Wiley, 2006.
2. C. M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2009.
- 3.S. Theodoridis and K. Koutroumbas, “Pattern Recognition”, 4th Edition, academic Press.
- 4.Robert Schalkoff, Pattern Recognition: Statistical, Structural and Neural approaches, JohnWiley & sons , Inc, 2007.



**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                                                                                                                                 | No of Lecture/Tutorial Hours |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                                       | <b>7</b>                     |
| 1.1 | Introduction to Pattern Recognition – Definitions and basic concepts                                                                                                  | 1                            |
| 1.2 | Data sets for patterns, application areas and examples                                                                                                                | 1                            |
| 1.3 | Design principles of a pattern recognition system                                                                                                                     | 1                            |
| 1.4 | Classification and clustering concepts                                                                                                                                | 2                            |
| 1.5 | Supervised learning, unsupervised learning and adaptation, Pattern recognition approaches, decision boundaries, decision regions, metric spaces and distance measures | 2                            |
|     | <b>Module 2</b>                                                                                                                                                       | <b>7</b>                     |
| 2.1 | Introduction to classification and applications                                                                                                                       | 1                            |
| 2.2 | Types of classification methods                                                                                                                                       | 1                            |
| 2.3 | Decision Tree and Naïve Bayes classifier                                                                                                                              | 1                            |
| 2.4 | Logistic Regression and Support Vector Machines,                                                                                                                      | 2                            |
| 2.5 | Random Forest and K-Nearest Neighbour (KNN) classifier and its variants                                                                                               | 1                            |
| 2.6 | Efficient algorithms for nearest neighbour classification, prototype selection, classifier combination, training and test sets, standardization and normalization     | 1                            |
|     | <b>Module 3</b>                                                                                                                                                       | <b>7</b>                     |
| 3.1 | Paradigms of pattern recognition and representation of patterns and classes                                                                                           | 1                            |
| 3.2 | Introduction to unsupervised learning and clustering                                                                                                                  | 1                            |
| 3.3 | Criterion functions for clustering                                                                                                                                    | 1                            |
| 3.4 | Iterative square-error partitional clustering                                                                                                                         | 1                            |
| 3.5 | K-Means clustering algorithm                                                                                                                                          | 1                            |
| 3.6 | Hierarchical clustering and cluster validation                                                                                                                        | 2                            |
|     | <b>Module 4</b>                                                                                                                                                       | <b>7</b>                     |
| 4.1 | Introduction to feature extraction and feature selection                                                                                                              | 1                            |
| 4.2 | Types of feature extraction and applications                                                                                                                          | 1                            |
| 4.3 | Problem statement in feature selection                                                                                                                                | 1                            |
| 4.4 | Branch and Bound algorithm                                                                                                                                            | 1                            |
| 4.5 | Sequential Forward Selection and Sequential Backward Selection algorithms                                                                                             | 2                            |
| 4.6 | (l, r) algorithm for feature selection                                                                                                                                | 1                            |
|     | <b>Module 5</b>                                                                                                                                                       | <b>7</b>                     |
| 5.1 | Recent advances in pattern recognition                                                                                                                                | 1                            |
| 5.2 | Structural pattern recognition                                                                                                                                        | 1                            |
| 5.3 | Support Vector Machines and Fuzzy C-Means clustering                                                                                                                  | 1                            |
| 5.4 | Soft computing and neuro-fuzzy techniques                                                                                                                             | 2                            |

|     |                                                                                                                 |                 |
|-----|-----------------------------------------------------------------------------------------------------------------|-----------------|
| 5.5 | Histogram rules and density estimation, Nearest neighbour rule, fuzzy classification and real-life applications | 2               |
|     | <b>Total Hours</b>                                                                                              | <b>35 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the basic components and design principles of a pattern recognition system with a suitable example.
2. Examine decision boundary, decision region, and metric space. Explain the importance of distance measures in pattern classification.

#### Course Outcome 2 (CO 2):

1. Explain the working principle of the K-Nearest Neighbour (KNN) classifier with an example.
2. Describe the Naïve Bayes classifier and discuss its advantages and limitations.

#### Course Outcome 3 (CO 3):

1. Discuss hierarchical clustering and differentiate between agglomerative and divisive clustering.
2. Explain criterion functions in clustering. Examine their role in cluster formation and evaluation.

#### Course Outcome 4 (CO 4):

1. Describe the Sequential Forward Selection and Sequential Backward Selection algorithms.
2. Explain the Branch and Bound algorithm for feature selection.

#### Course Outcome 5 (CO 5):

1. Explain Structural Pattern Recognition and its applications
2. Describe the Fuzzy C-Means (FCM) clustering algorithm and compare it with K-Means.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 2**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2028**

**Course Code: B24EC4P62**

**Course Name: PATTERN RECOGNITION**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define pattern recognition and mention two application areas.
2. Explain decision boundary and decision region.
3. Examine Naïve Bayes classifier.
4. Explain the concept of training set and test set.
5. Define clustering. Give two examples of clustering applications.
6. Discuss K-means clustering.
7. Explain feature extraction.
8. Distinguish between feature extraction and feature selection.
9. Explain Structural Pattern Recognitions.
10. Discuss Fuzzy classification.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain the basic components and design principles of a pattern recognition system with a neat diagram. (7)  
b) Discuss pattern recognition approaches and explain the role of metric spaces and distance measures in classification. (7)
12. a) Explain the concepts of supervised learning and unsupervised learning with suitable examples. (7)  
b) Describe decision boundaries and decision regions with appropriate illustrations. (7)

**Module II**

13. a) Explain the K-Nearest Neighbour (KNN) classifier with a suitable example. (7)  
b) Describe efficient algorithms for nearest neighbour classification and the concept of prototype selection. (7)
14. a) Explain the Naïve Bayes classifier and its advantages and limitations. (7)  
b) Discuss Support Vector Machine (SVM) and Random Forest classification techniques. (7)

**Module III**

15. a) Explain the K-Means clustering algorithm with steps and example. (7)  
b) Describe criterion functions used in clustering. (7)
16. a) Explain hierarchical clustering and differentiate between agglomerative and divisive clustering. (7)  
b) Discuss the concept and methods of cluster validation. (7)

**Module IV**

17. a) Explain the concept and importance of feature extraction in pattern recognition. (7)  
b) Describe different types of feature extraction techniques and their applications. (7)
18. a) Explain the Branch and Bound algorithm used for feature selection. (7)  
b) Describe Sequential Forward Selection and Sequential Backward Selection algorithms. (7)

**Module V**

19. a) Explain Structural Pattern Recognition with suitable examples. (7)  
b) Discuss Fuzzy C-Means (FCM) clustering algorithm. (7)
20. a) Explain histogram rules and density estimation in pattern recognition. (7)  
b) Discuss soft computing and neuro-fuzzy techniques used in pattern recognition. (7)

| B24EC4P63 | LOW POWER VLSI | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|----------------|---|---|---|---|--------|----------------------|
|           |                | 2 | 1 | 0 | 4 |        |                      |

### Preamble

This course aims to impart the basic knowledge in designing of Low power VLSI Circuits .

### Prerequisites

B24EC1T03 : LOGIC CIRCUIT DESIGN

B24EC2T04 : SOLID STATE DEVICES

B24EC3T04 : VLSI DESIGN

### Course Outcomes

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                             |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Explain the various short channel effects in MOSFETs. [Understand]                                                                                                          |
| <b>CO 2</b> | Understand and apply various sources of power dissipation in CMOS circuits, including dynamic, short-circuit, leakage, and gate-level power components. [Understand, Apply] |
| <b>CO 3</b> | Apply different power reduction techniques such as voltage scaling, transistor stacking, and power/clock gating in CMOS circuits. [Apply]                                   |
| <b>CO 4</b> | Apply different circuit design styles, including clocked and non-clocked logic families such as domino logic, DCVS, and pseudo-NMOS, for logic implementation. [Apply]      |
| <b>CO 5</b> | Apply adiabatic switching and reversible logic concepts for low-power circuit design. [Apply]                                                                               |

### Mapping of Course Outcomes With Program Outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 2    |      |      |      |      |      |      |      |       | 1     |
| <b>CO 2</b> | 3    | 3    | 1    | 2    | 2    |      |      |      |      |       | 1     |
| <b>CO 3</b> | 3    | 2    | 3    | 2    | 3    |      |      |      |      |       | 1     |
| <b>CO 4</b> | 3    | 2    | 3    | 2    | 3    |      |      |      |      |       | 1     |
| <b>CO 5</b> | 2    | 1    | 2    | 1    |      |      |      |      |      |       | 1     |



### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         | 10                    | 10                 | 10                                    |
| Understand       | 20                    | 20                 | 20                                    |
| Apply            | 20                    | 20                 | 70                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Course project/Assignment              | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## **SYLLABUS**

### **MODULE 1**

**Physics of Power dissipation in MOSFET devices:** Need for low power circuit design, MIS Structure, Short channel effects-surface scattering, punch through, velocity saturation, impact ionization Hot electron effects, Drain Induced Barrier Lowering, Deep submicron transistor design issues.

### **MODULE 2**

**Sources of power dissipation in CMOS:** Dynamic Power Dissipation: Charging and Discharging capacitance power dissipation , Short Circuit Power: Short Circuit Current of Inverter , Short circuit current dependency with input and output load , Glitching Power, Static Power Dissipation, Leakage Power Dissipation,

**Gate level power analysis :** Capacitive, internal and static power dissipation in gate-level circuits.

### **MODULE 3**

**Power Reduction Techniques:** Supply voltage Scaling Approaches: Multi VDD and Dynamic VDD, leakage power reduction Techniques – Transistor stacking, VTCMOS, MTCMOS, DTCMOS, Power gating, Clock gating for Dynamic power dissipation, Transistor and Gate Sizing for Dynamic and Leakage Power Reduction.

### **MODULE 4**

**Circuit design style:** Clocked design style- Basic concept, Domino logic (domino NAND gate), Differential Current Switch Logic. Non clocked circuit design style-fully complementary logic. NMOS and pseudo –NMOS logic, differential cascade voltage switch logic(DCVS)

### **MODULE 5**

**Adiabatic switching:** Adiabatic charging, adiabatic amplification, One stage and two stage adiabatic buffer, Adiabatic logic gates, pulsed power supplies, Reversible logic basic concepts.

### Text Books

1. Gray Yeap, Practical low power digital VLSI design, Springer, 2012
2. Kaushik Roy, Sharat C Prasad, Low power CMOS VLSI circuit design, Wiley India, 2000
3. Abdellatif Bellaouar, Mohamed I Elmasry, Low power digital VLSI design, Kluwer Academic, 2012
4. Anatha P Chandrakasan, Robert W Brodersen, Low power digital CMOS Design, Kluwer Academic, 2012
5. Christian Piguet, Low power CMOS circuits, Taylor & Francis, 2018
6. Kiat Seng Yeo, Kaushik Roy, Low voltage, low power VLSI sub systems, Tata McGraw Hill, 2005

### Simulation Assignments

Atleast one assignment should be simulation based that uses softwares like LT Spice, HSPICE/NGSPICE or Cadence Virtuoso. The design may be implemented using any clocked or non-clocked style, and power analysis should be performed. Samples of simulation assignments are given below.

1. Implement NAND gate in conventional CMOS and domino logic and perform power analysis in each case.
2. Implement any sample logic function in DCVS.
3. Apply threshold voltage scaling method to a logic function implemented in conventional style and perform power analysis.

## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                  | No of Lecture/Tutorial Hours |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                        | <b>6</b>                     |
| 1.1 | Need for low power circuit design, MIS Structure.                                                                                                      | 2                            |
| 1.2 | Short channel effects-surface scattering, punch through, velocity saturation, impact ionization, Hot electron effects, Drain Induced Barrier Lowering. | 3                            |
| 1.3 | Deep submicron transistor design issues.                                                                                                               | 1                            |
|     | <b>Module 2</b>                                                                                                                                        | <b>9</b>                     |
| 2.1 | Dynamic Power Dissipation: Charging and Discharging capacitance power dissipation.                                                                     | 1                            |
| 2.2 | Short Circuit Power: Short Circuit Current of Inverter , Short circuit current dependency with input and output load .                                 | 2                            |

|     |                                                                                                       |                 |
|-----|-------------------------------------------------------------------------------------------------------|-----------------|
| 2.3 | Glitching Power, Static Power Dissipation, Leakage Power Dissipation,                                 | 4               |
| 2.4 | Gate level power analysis : Capacitive, internal and static power dissipation in gate-level circuits. | 2               |
|     | <b>Module 3</b>                                                                                       | <b>7</b>        |
| 3.1 | Supply voltage Scaling Approaches: Multi VDD and Dynamic VDD.                                         | 1               |
| 3.2 | Leakage power reduction Techniques – Transistor stacking VTCMOS,MTCMOS, DTCMOS.                       | 2               |
| 3.3 | Power gating, Clock gating for Dynamic power dissipation.                                             | 2               |
| 3.4 | Transistor and Gate Sizing for Dynamic and Leakage Power Reduction.                                   | 2               |
|     | <b>Module 4</b>                                                                                       | <b>6</b>        |
| 4.1 | Clocked design style- Basic concept, Domino logic.                                                    | 2               |
| 4.2 | Differential Current Switch Logic.                                                                    | 1               |
| 4.3 | Non clocked circuit design style-fully complementary logic. NMOS and pseudo –NMOS logic.              | 2               |
| 4.4 | Differential Cascade Voltage Switch logic(DCVS).                                                      | 1               |
|     | <b>Module 5</b>                                                                                       | <b>7</b>        |
| 5.1 | Adiabatic charging, adiabatic amplification.                                                          | 3               |
| 5.2 | One stage and two stage adiabatic buffer.                                                             | 2               |
| 5.3 | Adiabatic logic gates, pulsed power supplies.                                                         | 1               |
| 5.4 | Reversible logic basic concepts.                                                                      | 1               |
|     | <b>Total Hours</b>                                                                                    | <b>35 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Identify the major short channel effects that occur in deep submicron MOSFETs.
2. Define velocity saturation and explain its effect on MOSFET current.
3. Identify the causes and effects of impact ionization in short channel devices.

#### Course Outcome 2 (CO 2):

1. List the major sources of power dissipation in CMOS circuits.
2. Identify the factors affecting dynamic power dissipation in CMOS circuits.
3. Explain the short circuit current that flows in a CMOS inverter during switching.

**Course Outcome 3 (CO 3):**

1. Explain the use of transistor and Gate sizing for power deduction.
2. Describe supply voltage scaling method for power reduction.
3. Discuss various power reduction schemes to memory cells.

**Course Outcome 4 (CO 4):**

1. Implement XOR gate in domino logic.
2. Implement the function  $F = [AB + CD]$  in DCVS.
3. Implement basic gates in nmos and pseudo nmos logic.

**Course Outcome 5 (CO 5):**

1. Implement  $Y = AB$  using adiabatic logic.
2. Explain one stage adiabatic buffer.
3. Implement logic functions using different Reversible logic structures.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2028**

***Course Code: B24EC4P63***

***Course Name: LOW POWER VLSI***

**Max. Marks: 100**

**Duration: 3 hours**

***PART A***

***Answer all questions. Each question carries 3 marks***

1. Define the terms a) DIBL b) Velocity Saturation.
2. Discuss the need for low power VLSI Design.
3. Explain the dependency of short circuit current with output load?
4. Explain dynamic power dissipation?
5. Explain leakage power reduction using MTCMOS.
6. Define Slack time of logic gate.
7. List the advantages and Disadvantages of Clocked design.
8. Explain the methods to overcome charge sharing problem.
9. Draw the schematic and logic symbol of an Adiabatic amplifier.
10. List the disadvantages of Retractable cascade of Adiabatic logic Gates.

***PART B***

***Answer any one question from each module. Each question carries 14 marks***

***Module I***



11. a) Explain the energy band diagram of MIS structure. (8)  
b) Discuss the various transistor leakage mechanisms in deep submicron transistors. (6)
12. a) Explain various short channel effects. (8)  
b) Explain how the power efficiency of a chip can be measured? (6)

### ***Module II***

13. a) Explain how capacitance can be estimated at gate level? (7)  
b) Explain the formation of glitches in circuits ? Explain various methods for eliminating the glitches. (7)
14. a) Explain the various sources of leakage power in MOSFET. (7)  
b) A 16 bit bus operating in 5V and 66MHz clock rate is driving capacitance of 2pF/Bit. Each bit is estimated to have a toggling probability of 0.25 at each clock cycle. Calculate the power dissipated in operating the bus. (7)

### ***Module III***

15. a) Illustrate with examples how low threshold device and high threshold device can be effectively used for power reduction. (7)  
b) Explain dynamic supply voltage scaling mechanism for power reduction. (7)
16. a) Briefly explain dynamic and leakage power reduction using transistor sizing. (7)  
b) Illustrate various mechanisms by which power consumption of 6T RAM cells can be reduced. (7)

### ***Module IV***

17. a) Implement the function  $F = [(a+b)(c+d)]'$  in NMOS logic and domino logic. (7)  
b) Implement the function  $F = (A+CD)$  in DCVS logic. (7)
18. a) Explain how charge sharing problem occur in logic design. How it can be eliminated? (7)  
b) Differentiate precharge high and precharge low DCSL. (7)

### ***Module V***

19. a) Describe the working of one stage adiabatic buffer. (7)  
b) Explain pulsed power supply? Describe its importance in adiabatic logic. (7)
20. a) Describe various reversible gate structures. (7)  
b) Implement OR and AND function using Fredkin gate. (7)

| <b>B24EC4P64</b> | <b>COMPUTER<br/>VISION</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF<br/>INTRODUCTION</b> |
|------------------|----------------------------|----------|----------|----------|----------|---------------|---------------------------------|
|                  |                            | 2        | 1        | 0        | 4        |               |                                 |

**Preamble**

This course aims to develop the knowledge of various methods, algorithms and applications of Computer Vision.

**Prerequisites**

B24EC4P33 : DIGITAL IMAGE PROCESSING

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                   |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand digital filtering operations for CV applications. [Understand]                                                                                         |
| <b>CO 2</b> | Apply basic morphological and boundary operators for Computer vision applications. [Apply]                                                                        |
| <b>CO 3</b> | Apply edge, corner detection algorithms to locate objects in an image. [Apply]                                                                                    |
| <b>CO 4</b> | Apply optical flow algorithms to detect moving objects in a video. [Apply]                                                                                        |
| <b>CO 5</b> | Analyse a given scene using appropriate computer vision algorithms to detect/recognize objects and to implement it in real time practical applications. [Analyse] |

**Mapping of Course Outcomes With Program Outcomes**

|             | <b>PO 1</b> | <b>PO 2</b> | <b>PO 3</b> | <b>PO 4</b> | <b>PO 5</b> | <b>PO 6</b> | <b>PO 7</b> | <b>PO 8</b> | <b>PO 9</b> | <b>PO 10</b> | <b>PO 11</b> |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|
| <b>CO 1</b> | 3           | 3           | 2           |             | 2           |             | 1           |             |             |              | 2            |
| <b>CO 2</b> | 3           | 3           | 2           |             | 2           |             |             |             |             |              | 2            |
| <b>CO 3</b> | 3           |             | 3           | 3           |             | 2           |             |             |             |              | 2            |
| <b>CO 4</b> | 3           | 3           | 3           |             | 2           |             |             |             |             |              | 2            |
| <b>CO 5</b> | 3           | 3           | 3           |             | 2           |             |             |             |             |              | 2            |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## **SYLLABUS**

### **MODULE 1**

**Review of image processing techniques:** Point operators- Histogram, neighbourhood operators, thresholding. Filters: Spatial domain and frequency domain filtering, Laplacian filter, Homomorphic filtering.

### **MODULE 2**

**Binary Operations:** Mathematical morphology, Binary shape analysis, Binary shape analysis, Erosion, Dilation, Opening and Closing, Hit-or-Miss Transform, connectedness, object labelling and counting, Boundary descriptors – Chain codes. Properties of Binary Regions, Geometric Features, Statistical Shape Properties.

### **MODULE 3**

**Feature Detection:** Feature Detection and Image Synthesis, Edge detection – edges, lines, active contours, Split and merge, Mean shift and mode finding, Normalized cuts, Graph cuts, energy- based methods- Cranny's Algorithm, Corner detection, Harris corner detection algorithm. Hough transform-Line and curve detection.

### **MODULE 4**

**Motion Analysis:** Shape from X - Shape from shading, Photometric stereo, Texture Occluding contour detection. Motion Analysis- Regularization theory, Optical Flow: brightness constancy equation, aperture problem, Horn-Shunck method, Lucas-Kanade method. Structure from motion.

### **MODULE 5**

**Applications of Computer Vision:** Object recognition-Shape correspondence and shape matching PCA, SVM, LDA, Bayes rule and ML methods. Eigen faces, Face detection, Face recognition, Application: Scene analysis, Examples of real time applications: In-vehicle vision system.

### **Text Books**

1. E. R .Davies, Computer and Machine Vision -Theory Algorithm and Practicalities, Academic Press, 2012
2. Richard Szeliski, Computer Vision: Algorithms and Applications, ISBN 978-1- 84882-935-0, Springer 2011.
3. David Forsyth and Jean Ponce, Computer Vision: A Modern Approach, Pearson India,

2002.

### **Reference Books**

1. Goodfellow, Bengio, and Courville, Deep Learning, MIT Press, 2006.
2. Daniel Lelis Baggio, KhvedcheniaIevgen, Shervin Emam, David Millan Escrava, Naureen-Mahmoo, Jason Saragi, Roy Shilkrot, Mastering OpenCV with Practical Computer Vision Projects, Packt Publishing Limited, 2012.
3. Simon J D Prince, Computer Vision: Models, Learning, and Inference, Cambridge University Press, 2012.
4. R. J. Schalkoff, Digital Image Processing and Computer Vision, John Wiley, 2004.
5. D. L. Baggio et al., Mastering OpenCV with Practical Computer Vision Projects, Packt Publishing, 2012.
6. Jan Erik Solem, Programming Computer Vision with Python: Tools and algorithms for analyzing images, O'Reilly Media, 2012.

**COURSE CONTENTS AND LECTURE SCHEDULE**

| No  | Topic                                                                                                                                                                            | No of Lecture/Tutorial Hours |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                                                  | <b>5</b>                     |
| 1.1 | Review of image processing techniques, Point operators- Histogram, neighbourhood operators, Thesholding.                                                                         | 2                            |
| 1.2 | Spatial domain and frequency domain filtering.                                                                                                                                   | 2                            |
| 1.3 | Laplacian filter, Homomorphic filtering.                                                                                                                                         | 1                            |
|     | <b>Module 2</b>                                                                                                                                                                  | <b>6</b>                     |
| 2.1 | Erosion, Dilation, Opening and Closing, Hit-or-Miss Transform, structuring element                                                                                               | 2                            |
| 2.2 | Binary shape analysis, Connected components- Connected component labelling, Boundary descriptors – Chain codes.                                                                  | 2                            |
| 2.3 | Properties of Binary Regions, Geometric Features , Statistical Shape Properties                                                                                                  | 2                            |
|     | <b>Module 3</b>                                                                                                                                                                  | <b>5</b>                     |
| 3.1 | Edge detection – edges, lines, active contours, Split and merge, Mean shift and mode finding, Normalized cuts, Graph cuts, energy-based method- Canny's edge detection Algorithm | 2                            |
| 3.2 | Corner detection, Harris corner detection algorithm                                                                                                                              | 1                            |
| 3.3 | Hough transform Algorithm for Line and curve detection                                                                                                                           | 2                            |
|     | <b>Module 4</b>                                                                                                                                                                  | <b>10</b>                    |
| 4.1 | Shape from X - Shape from shading, Photometric stereo, Texture                                                                                                                   | 2                            |
| 4.2 | Motion Analysis- Regularization theory, Optical Flow: brightness constancy equation, aperture problem                                                                            | 3                            |
| 4.3 | Horn-Shunck Algorithm and Lucas-Kanade Algorithm for detection of optical flow                                                                                                   | 3                            |
| 4.4 | Structure from motion                                                                                                                                                            | 2                            |
|     | <b>Module 5</b>                                                                                                                                                                  | <b>9</b>                     |
| 5.1 | Object Detection and Object classification algorithms: SVM, PCA, Linear discriminant analysis, Bayes rule, ML methods.                                                           | 3                            |
| 5.2 | Face detection, Face Recognition, Eigen faces, 3D face models                                                                                                                    | 2                            |
| 5.3 | Applications of computer vision: Scene Analysis and scene understanding, Examples of real time applications: In-vehicle vision system                                            | 3                            |
|     | <b>Total Hours</b>                                                                                                                                                               | <b>35 Hours</b>              |



## **CO ASSESSMENT QUESTIONS**

### **Course Outcome 1 (CO 1):**

1. Explain the role of histogram transformation and thresholding in improving grayscale images for computer vision applications.
2. Explain spatial domain and frequency domain filtering techniques used in computer vision. Discuss the working principles of Laplacian filtering and homomorphic filtering.

### **Course Outcome 2 (CO 2):**

1. Explain the working of spatial filtering and demonstrate how smoothing filters reduce noise in images.
2. Describe the connected component labeling algorithm and explain how it is used for object identification in binary images.

### **Course Outcome 3 (CO 3):**

1. Explain the Canny edge detection algorithm and discuss its advantages in computer vision applications.
2. Describe the Harris corner detection algorithm and explain how corners are detected in an image.

### **Course Outcome 4 (CO 4):**

1. Derive the brightness constancy equation used in optical flow computation.
2. Explain the Lucas–Kanade optical flow algorithm and describe how it is used to detect motion in video sequences.

### **Course Outcome 5 (CO 5):**

1. Explain how Principal Component Analysis (PCA) is used for face recognition in computer vision systems.
2. Describe how deep learning methods such as CNN or YOLO can be used for object detection in images and videos.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 3**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2028**

***Course Code: B24EC4P64***

***Course Name: COMPUTER VISION***

**Max. Marks: 100**

**Duration: 3 hours**

***PART A***

***Answer all questions. Each question carries 3 marks***

1. Write down the Sobel, Robert and Prewitt masks?
2. Give a 3x3 convolution mask to shift a 256x256 image one pixel position to right.?
3. Name three computer vision applications where object labelling and counting is applied.?
4. Describe steps in identifying connected components in an 8- connectivity case.?
5. Write down basic Hough transform algorithm?
6. Compare and contrast normalised cut and graph cut methods.?
7. Mention the concept of identifying structure from motion.?
8. Define texture? What is its role in object recognition?
9. Define Eigen values and Eigen vectors.?
10. Differentiate between SVM and LDA.?

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Describe point operators with illustrative diagrams.? (6)  
b) Explain spatial domain and frequency domain filtering techniques used in image processing. Compare their advantages? (8)
12. a) What is thresholding? Briefly describe different methods of thresholding? (6)  
b) Describe homomorphic filtering and explain how it improves image contrast and illumination? (8)

**Module II**

13. a) Describe Geometric features and Statistical properties of a binary region. (6)  
b) A binary image  $A$  and structuring element  $B$  are given below.

**Binary Image  $A$**

$$A = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

**Structuring Element  $B$**

$$B = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

The origin of the structuring element is at the center.

- i. Perform erosion ( $A \ominus B$ ).  
ii. Perform dilation ( $A \oplus B$ ). (7)
14. a) Explain the concept of connectedness in binary images and differentiate between 4-connectivity and 8-connectivity.? (7)  
b) Using the Hoshen–Kopelman algorithm, assign connected component labelling for the given image pixels marked as 'x' in the diagram below.

|   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|
| x | x |   |   |   |   |   |   |
| x | x | x | x |   |   |   |   |
| x | x | x | x | x | x | x | x |
| x | x | x | x |   |   |   |   |
| x | x | x | x | x |   |   |   |

(7)

**Module III**

15. a) Describe how Mean shift algorithm locate maxima of a density function in computer vision applications.? (7)  
b) Interpret different steps involved in Harris corner detection algorithm and describe how it is applied to detect corners in an image? (7)
16. a) Give Canny's algorithm and describe how it can be applied to detect edges of an image.? (7)  
b) Write down Hough Transform algorithm and explain how it can be employed to locate coins in a given image.? (7)

**Module IV**

17. a) Give Lucas-Kannade algorithmic with each steps and explain how it is employed for motion detection.? (7)  
b) Briefly explain the following concepts: (i) Photometric stereo (ii) Shape from -X (7)
18. a) Derive brightness constancy equation.? (6)  
b) Describe with algorithmic steps, the Horn-Shunk method used for the estimation of optical flow.? (8)

**Module V**

19. a) Describe how LDA is employed for dimensionality reduction, with different mathematical steps involved.? (7)  
b) Find Principal components of the following matrix

$$A = \begin{bmatrix} 8 & -8 & -2 \\ 4 & -3 & -2 \\ 3 & -4 & 1 \end{bmatrix}$$

20. a) What is an Eigen face? Derive the equation for Eigen faces and Explain its importance in a face recognition system.? (7)  
b) Illustrate the operation of an in-vehicle vision system, for locating roadways and pedestrians, as a real time practical application of computer vision.? (7)

| <b>B24EC4P65</b> | <b>SATELLITE<br/>COMMUNICA-<br/>TION</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF<br/>INTRODUCTION</b> |
|------------------|------------------------------------------|----------|----------|----------|----------|---------------|---------------------------------|
|                  |                                          | 2        | 1        | 0        | 4        |               |                                 |

**Preamble**

This course aims to impart the basic knowledge of satellite communication and its applications.

**Prerequisites**

B24EC3T03 : ANALOG AND DIGITAL COMMUNICATION

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                      |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Define satellite communications & possible satellite orbits. [Understand,Apply]                                                      |
| <b>CO 2</b> | Describe satellite communication subsystems & launching mechanisms of satellites. [Understand, Apply]                                |
| <b>CO 3</b> | Calculate link budgets. Provide an in-depth treatment of satellite communication systems operation and planning. [Understand, Apply] |
| <b>CO 4</b> | Analyze the various methods of satellite access. [Understand, Apply]                                                                 |
| <b>CO 5</b> | Discuss various applications of satellite communications. [Understand, Apply]                                                        |

**Mapping of Course Outcomes With Program Outcomes**

|             | <b>PO 1</b> | <b>PO 2</b> | <b>PO 3</b> | <b>PO 4</b> | <b>PO 5</b> | <b>PO 6</b> | <b>PO 7</b> | <b>PO 8</b> | <b>PO 9</b> | <b>PO 10</b> | <b>PO 11</b> |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|
| <b>CO 1</b> | 3           | 3           | 1           |             |             |             |             |             |             |              |              |
| <b>CO 2</b> | 3           | 3           |             | 1           |             |             |             |             | 1           |              |              |
| <b>CO 3</b> | 3           | 3           | 3           |             | 1           |             |             | 1           |             |              | 1            |
| <b>CO 4</b> | 3           | 3           |             |             | 2           |             | 1           |             |             | 1            |              |
| <b>CO 5</b> | 3           | 3           |             |             |             | 1           |             |             | 1           |              |              |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.



## **SYLLABUS**

### **MODULE 1**

**Satellite Orbits:** Introduction to Satellite Communication, Historical background, Basic concepts of Satellite Communications, Kepler's laws of planetary motion, types of satellite orbits, orbit determination. Definitions of terms for Earth-Orbiting Satellites, Orbital Elements, Apogee and Perigee Heights, satellite stabilization, orbital effects on satellites performance. Antenna Look Angles, The Polar Mount Antenna, Limits of Visibility, launch systems for geostationary satellites.

### **MODULE 2**

**Satellite System:**

The Space Segment Introduction, The Power Supply, Attitude & Orbit Control, Satellite stabilization, Station Keeping, Thermal Control, TT&C Subsystem, Transponders, Antenna Subsystem.

The Earth Segment Types of earth station, architecture & design considerations. Transmit-Receive Earth Station, Wideband receiver, the input demultiplexer, the power amplifier, Satellite tracking.

### **MODULE 3**

**The Satellite Link design:** Introduction, Transmission Theory, System Noise Temperature and G/T Ratio, Design of Downlinks Ku-Band GEO Satellite Systems, Uplink Design, Design for Specified CNR: Combining CNR and C/I Values in Satellite Links, System Design for Specific Performance. Regional & global satellite systems INSAT, INTELSAT & INMARSAT.

### **MODULE 4**

**Modulation & Multiple Access:** Introduction, Digital Modulation techniques preferred in satellites, Multiple Access, Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Transmitter Power in TDMA Networks, Demand Assignment Multiple Access (DAMA), Random Access (RA), Packet Radio Systems and Protocols, Code Division Multiple Access (CDMA).

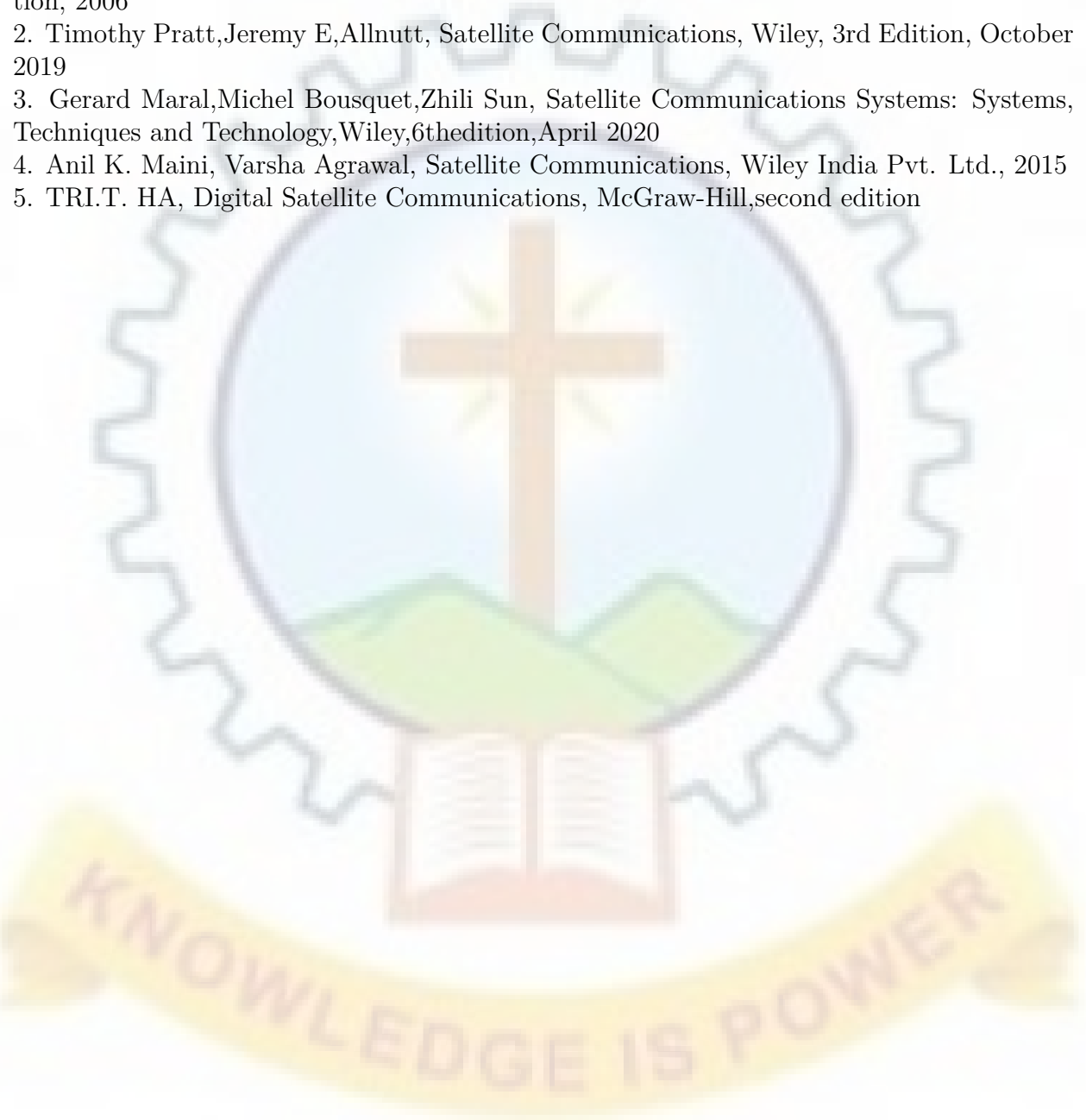
### **MODULE 5**

**Satellite Application:** Introduction, Frequency bands, Comparison between Satellite & terrestrial networks, Satellite Telephony, Satellite Television, DTH, Satellite Radio broadcasting, Remote Sensing Satellite; Classification, orbits, payloads, Weather Forecasting Satel-

lites:Orbits, payloads. Navigation Satellite:Basic principles of satellite navigation, GPS Position Location Principle functional segments of GPS, Indian Contribution to positioning systems. NGSO satellite systems.

**Text Books**

1. Dennis Roddy, Satellite Communications, 4th Edition, McGraw- Hill International edition, 2006
2. Timothy Pratt,Jeremy E,Allnutt, Satellite Communications, Wiley, 3rd Edition, October 2019
3. Gerard Maral,Michel Bousquet,Zhili Sun, Satellite Communications Systems: Systems, Techniques and Technology,Wiley,6thedition,April 2020
4. Anil K. Maini, Varsha Agrawal, Satellite Communications, Wiley India Pvt. Ltd., 2015
5. TRI.T. HA, Digital Satellite Communications, McGraw-Hill,second edition



**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                                                                                    | <b>No of Lecture/Tutorial Hours</b> |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1: Satellite Orbits</b>                                                                                                                                               | <b>7</b>                            |
| 1.1       | Introduction to Satellite Communication, Historical background, Basic concepts of Satellite Communication                                                                       | 1                                   |
| 1.2       | Kepler's laws of planetary motion, types of satellite orbits, orbit determination.                                                                                              | 2                                   |
| 1.3       | Definitions of terms for Earth-Orbiting Satellites, Orbital Elements, Apogee and Perigee Heights.                                                                               | 1                                   |
| 1.4       | Satellite stabilization, orbital effects on satellites performance.                                                                                                             | 1                                   |
| 1.5       | Antenna Look Angles, The Polar Mount Antenna, Limits of Visibility.                                                                                                             | 1                                   |
| 1.6       | Launch systems for geostationary satellites.                                                                                                                                    | 1                                   |
|           | <b>Module 2: Satellite System</b>                                                                                                                                               | <b>7</b>                            |
| 2.1       | The Space Segment Introduction, The Power Supply, Attitude & Orbit Control, Satellite stabilization, Station Keeping, Thermal Control.                                          | 2                                   |
| 2.2       | TT & C Subsystem, Transponders.                                                                                                                                                 | 1                                   |
| 2.3       | Antenna Subsystem, Antenna types & design equation (derivation not required)                                                                                                    | 1                                   |
| 2.4       | The Earth Segment Types of earth station, architecture & design considerations Transmit-Receive Earth Station ,                                                                 | 2                                   |
| 2.5       | Wide band receiver, The input demultiplexer, The power amplifier, Satellite tracking.                                                                                           | 1                                   |
|           | <b>Module 3: The Satellite Link design</b>                                                                                                                                      | <b>6</b>                            |
| 3.1       | Introduction, Transmission Theory , System Noise Temperature and G/T Ratio , Design of Downlinks Ku-Band GEO Satellite Systems                                                  | 2                                   |
| 3.2       | Uplink Design , Design for Specified CNR: Combining CNR and C/I Values in Satellite Links ,System Design for Specific Performance                                               | 2                                   |
| 3.3       | Regional & global satellite systems INSAT,INTELSAT & INMARSAT.                                                                                                                  | 2                                   |
|           | <b>Module 4: Modulation &amp; Multiple Access</b>                                                                                                                               | <b>7</b>                            |
| 4.1       | Introduction, Digital Modulation techniques preferred in satellite communication.                                                                                               | 2                                   |
| 4.2       | Multiple Access ,Frequency Division Multiple Access (FDMA) ,Time Division Multiple Access (TDMA), Transmitter Power in TDMA Networks, Demand Assignment Multiple Access (DAMA), | 2                                   |

|     |                                                                                                                                                                                                 |                 |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 4.3 | Random Access (RA) , Packet Radio Systems and Protocols, Code Division Multiple Access (CDMA)                                                                                                   | 3               |
|     | <b>Module 5: Satellite Application:</b>                                                                                                                                                         | <b>8</b>        |
| 5.1 | Introduction, Frequency bands, , Comparison between Satellite & terrestrial networks,                                                                                                           | 1               |
| 5.2 | Satellite Telephony, Satellite Television, DTH, Satellite Radio broadcasting,                                                                                                                   | 2               |
| 5.3 | Remote Sensing Satellite; Classification, orbits, payloads, Weather Forecasting Satellites: Orbits, payloads.                                                                                   | 2               |
| 5.4 | Navigation Satellite: Basic principles of satellite navigation, GPS Position Location Principle functional segments of GPS. Indian Contribution to positioning systems, NGSO satellite systems. | 3               |
|     | <b>Total Hours</b>                                                                                                                                                                              | <b>35 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the different types of satellite orbits?
2. Describe various orbital elements
3. Describe the effect of orbits on satellite performance?

#### Course Outcome 2 (CO 2):

1. Describe the major subsystems of a communication satellite .
2. Describe the significance of antenna subsystem why uplink and downlink frequency different in satellite communication are different.

#### Course Outcome 3 (CO 3):

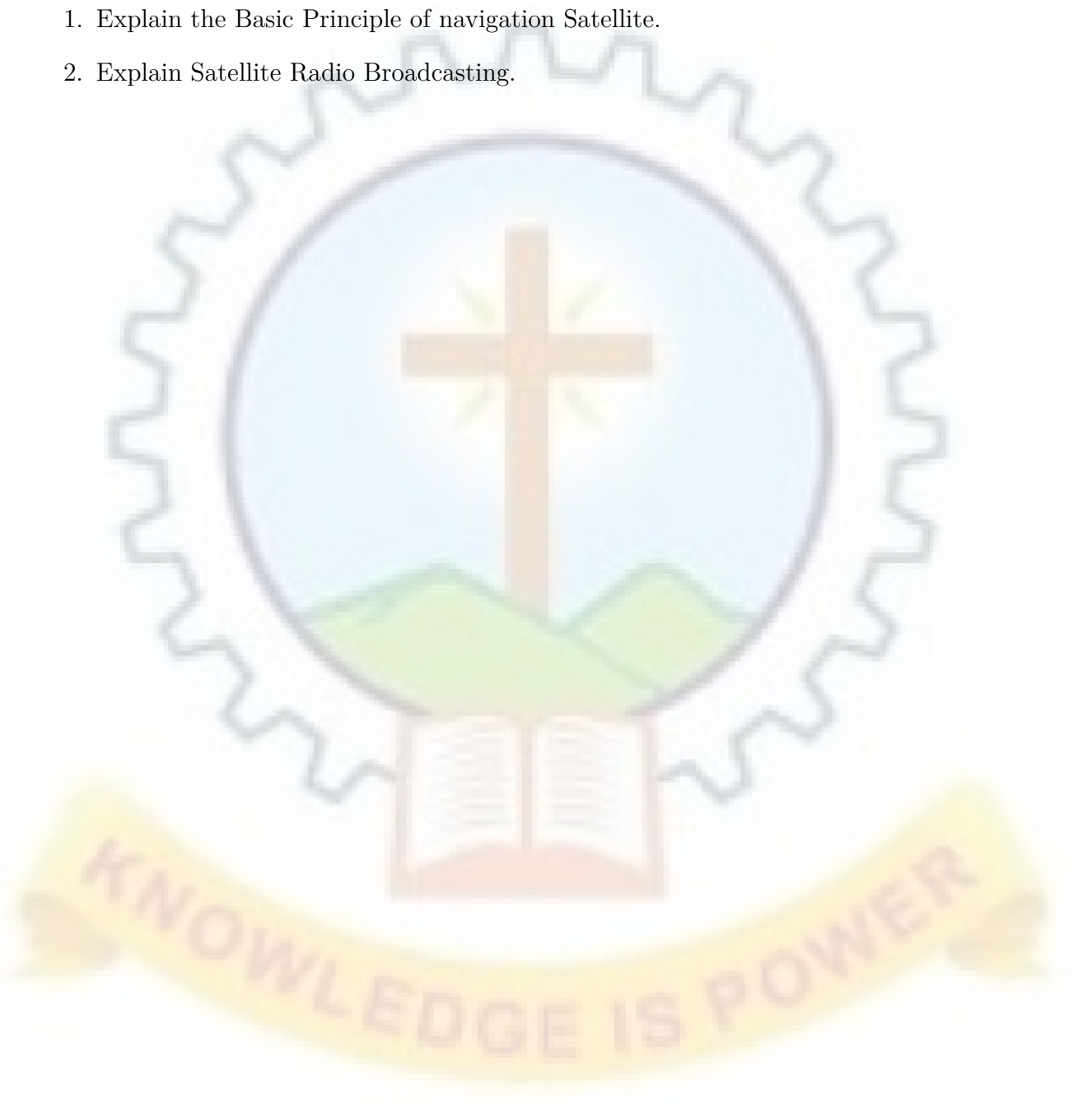
1. Calculation of total link loss for various sky condition
2. Calculation of Effective Isotropic Radiated Power required for various Sky Conditions.

#### Course Outcome 4 (CO 4):

1. Describe various multiple Access Technique.
2. Compare the uplink power requirement for FDMA and TDMA

**Course Outcome 5 (CO 5):**

1. Explain the Basic Principle of navigation Satellite.
2. Explain Satellite Radio Broadcasting.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2028**

**Course Code: B24EC4P65**

**Course Name: Satellite Communication**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. How do geostationary and geosynchronous orbit differ?
2. What are the limits of visibility of a satellite?
3. How thermal control achieved in space craft? Why is it necessary?
4. What is the need of tracking a spacecraft & how is it practiced?
5. Briefly describe the causes of interference and noise in a satellite link?
6. Why uplink and downlink frequency different in satellite communication?
7. State the advantages of demand assignment over preassigned access techniques?
8. Why synchronization is a must for TDMA?
9. Compare satellite & terrestrial networks?
10. State the orbital requirements & payload of a remote sensing satellite? Give one example of remote sensing satellite.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**



11. a) State Kepler's laws of planetary motion. Using these laws determine the height of geostationary orbit. (8)  
b) Discuss the various satellite orbits and their applications. (6)
12. a) Explain the need for stabilization of a space craft & methods to achieve it. (7)  
b) Briefly describe the launching methods & Launch vehicles used for putting a spacecraft into geostationary orbit. (7)

**Module II**

13. Discuss the major subsystems of a communication satellite. (14)
14. With a block schematic describe a transmit receive earth station (14)

**Module III**

15. Derive the uplink and downlink design of a geostationary Ku band satellite (14)
16. a) Discuss the regional communication satellite of India. (7)  
b) How global coverage is possible using INTELSAT. What is the use of INMARSAT (7)

**Module IV**

17. Discuss the digital modulation techniques used in satellite communication. (14)
18. (a) Discuss the Random-access techniques and the associated protocols. (7)  
(b) Compare FDMA, TDMA, CDMA. (7)

**Module V**

19. (a) Discuss direct broadcast satellite and satellite radio enumerating their advantages (7)  
(b) Discuss the weather forecasting satellites explaining the orbits chosen and the payload, and applications (7)
20. (a) Explain the functional system of a GPS. How position determined in GPS system and methods to reduce error. (7)  
(b) Explain NGSO satellite constellations. (7)

| B24EC4G31 | MACHINE<br>LEARNING | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|---------------------|---|---|---|---|--------|-------------------------|
|           |                     | 2 | 1 | 0 | 4 | 3      | 2024                    |

**Preamble**

This course introduces the fundamental concepts, mathematical foundations, and practical techniques of machine learning. It begins with an overview of machine learning principles, including data preprocessing, statistical foundations, and optimization methods. The course then explores various learning paradigms such as supervised and unsupervised learning, followed by modern deep learning architectures including neural networks, convolutional neural networks, and recurrent neural networks.

**Prerequisites**

Basic knowledge of linear algebra, probability theory and statistics

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                                                                                                 |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the fundamental concepts of machine learning, including its scope, limitations, mathematical foundations, data preprocessing techniques, and different learning paradigms such as supervised and unsupervised learning. [Understand] |
| <b>CO 2</b> | Understand and implement neural network models by understanding activation functions, loss functions, gradient descent, backpropagation, regularization techniques, and hyperparameter tuning. [Understand, Apply]                              |
| <b>CO 3</b> | Understand the architecture and working principles of Convolutional Neural Networks (CNNs) and apply them for image-based learning tasks using modern deep learning frameworks. [Understand, Apply]                                             |
| <b>CO 4</b> | Interpret and apply sequential learning models such as Recurrent Neural Networks (RNNs), LSTM and reinforcement learning techniques for sequence prediction and decision-making problems. [Understand, Apply]                                   |
| <b>CO 5</b> | Understand machine learning techniques such as Support Vector Machines and Bayesian learning and analyze their applications in areas like computer vision, speech processing, and natural language processing. [Understand, Apply]              |

**Mapping of Course Outcomes With Program Outcomes**

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    |      |      |      |      |      |      |      |       |       |
| CO 2 | 3    | 3    | 2    | 2    | 2    | 2    |      |      |      |       |       |
| CO 3 | 2    | 3    | 3    | 3    | 2    | 3    |      |      |      |       |       |
| CO 4 | 2    | 3    | 2    | 3    | 2    |      |      |      |      |       |       |
| CO 5 | 2    | 2    | 2    | 2    | 3    | 2    | 2    |      |      |       |       |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Introduction to Machine Learning:** Introduction to machine learning, scope and limitations, Supervised ML, Unsupervised ML, regression, probability, statistics and linear algebra for machine learning, convex optimization, data visualization, hypothesis function and testing, data distributions, data preprocessing, data augmentation, normalizing data sets.

### MODULE 2

**Fundamentals of Neural Networks and Deep Learning:** Linearity vs non linearity, activation functions like sigmoid, ReLU, etc., weights and bias, loss function, gradient descent, multilayer network, backpropagation, weight initialization, training, testing, unstable gradient problem, batch normalization, dropout, L1 and L2 regularization, momentum, tuning hyper parameters.

### MODULE 3

**Convolutional Neural Networks and Deep Learning Frameworks:** Convolutional neural network, flattening, subsampling, padding, stride, convolution layer, pooling layer, loss layer, dense layer, 1x1 convolution, transfer learning, one shot learning, dimension reductions, implementation of CNN like tensor flow, keras etc.

### MODULE 4

**Recurrent Neural Networks and Reinforcement Learning:** Recurrent neural network, Long short-term memory, translation, beam search and width, Evaluation metrics: Confusion matrix, recall, precision, accuracy. Reinforcement Learning, RL-framework, Value Iteration and Policy Iteration, Actor-critic model, Q-learning, SARSA

### MODULE 5

**Advanced Machine Learning Algorithms:** Support Vector Machines, Bayesian learning, application of machine learning in computer vision, speech processing, natural language processing etc, Case Study: ImageNet Competition

#### Text Books

1. Tom M. Mitchell, "Machine Learning", McGraw Hill Education, First edition, 2017

2. Ian Goodfellow and Yoshua Bengio and Aaron Courville, “Deep Learning”, MIT Press, 2016
3. Christopher M. Bishop, “Pattern Recognition and Machine Learning”, Springer-Verlag New York Inc., 2nd Edition, 2011.



## COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                  | No of Lecture/Tutorial Hours |
|-----|------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                        | <b>6</b>                     |
| 1.1 | Introduction to Machine Learning, scope and limitations                                                                | 1                            |
| 1.2 | Basic concepts of regression, probability and statistics for machine learning                                          | 1                            |
| 1.3 | Linear algebra concepts for machine learning                                                                           | 1                            |
| 1.4 | Convex optimization and hypothesis functions                                                                           | 1                            |
| 1.5 | Data distributions and hypothesis testing, Data preprocessing, data augmentation and normalization of datasets,        | 2                            |
|     | <b>Module 2</b>                                                                                                        | <b>6</b>                     |
| 2.1 | Linearity vs non-linearity, activation functions                                                                       | 1                            |
| 2.2 | Weights, bias and loss functions                                                                                       | 1                            |
| 2.3 | Gradient descent and multilayer neural networks                                                                        | 1                            |
| 2.4 | Backpropagation and weight initialization                                                                              | 1                            |
| 2.5 | Training, testing and unstable gradient problem                                                                        | 1                            |
| 2.6 | Regularization techniques: Batch normalization, dropout, L1 and L2 regularization, momentum and hyperparameter tuning. | 1                            |
|     | <b>Module 3</b>                                                                                                        | <b>6</b>                     |
| 3.1 | Introduction to Convolutional Neural Networks (CNN)                                                                    | 1                            |
| 3.2 | Convolution layer, padding, stride and input channels                                                                  | 1                            |
| 3.3 | Pooling layer, subsampling and flattening                                                                              | 1                            |
| 3.4 | Dense layer, loss layer and $1 \times 1$ convolution                                                                   | 1                            |
| 3.5 | Transfer learning, one-shot learning, dimension reduction and implementation using frameworks (TensorFlow, Keras)      | 1                            |
| 3.6 | Implementation of image or text classification problems                                                                | 1                            |
|     | <b>Module 4</b>                                                                                                        | <b>6</b>                     |
| 4.1 | Introduction to Recurrent Neural Networks (RNN)                                                                        | 1                            |
| 4.2 | Long Short-Term Memory (LSTM)                                                                                          | 1                            |
| 4.3 | Sequence applications: Translation, beam search and beam width                                                         | 1                            |
| 4.4 | Evaluation metrics: Confusion matrix, recall, precision, accuracy.                                                     | 1                            |
| 4.5 | Reinforcement learning framework                                                                                       | 1                            |
| 4.6 | Value iteration, policy iteration, actor-critic model, Q-learning and SARSA.                                           | 1                            |
|     | <b>Module 5</b>                                                                                                        | <b>6</b>                     |
| 5.1 | Support Vector Machines                                                                                                | 1                            |
| 5.2 | Bayesian learning                                                                                                      | 1                            |
| 5.3 | Applications of machine learning in computer vision                                                                    | 1                            |
| 5.4 | Applications in speech processing                                                                                      | 1                            |



|     |                                                                               |                 |
|-----|-------------------------------------------------------------------------------|-----------------|
| 5.5 | Applications in natural language processing, Case study: ImageNet Competition | 2               |
|     | <b>Total Hours</b>                                                            | <b>30 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the scope and limitations of machine learning. Discuss different types of learning such as supervised and unsupervised learning with examples.
2. Describe the role of probability, statistics, and linear algebra in machine learning.

#### Course Outcome 2 (CO 2):

1. Explain the working of activation functions such as sigmoid and ReLU.
2. Describe gradient descent and backpropagation algorithms used in training neural networks.

#### Course Outcome 3 (CO 3):

1. Describe the concepts of padding, stride, and subsampling in CNNs.
2. Discuss the use of deep learning frameworks such as TensorFlow or Keras in CNN implementation.

#### Course Outcome 4 (CO 4):

1. Explain the architecture and working of Recurrent Neural Networks (RNN).
2. Explain SARSA

#### Course Outcome 5 (CO 5):

1. Explain the principle of Support Vector Machines (SVM) and the concept of margin maximization.
2. Discuss applications of machine learning in computer vision, speech processing, and natural language processing with suitable examples.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 2**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2028**

**Course Code: B24EC4G31**

**Course Name: MACHINE LEARNING**

Max. Marks: 100

Duration: 3 hours

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Define Machine Learning. Explain its scope and limitations.
2. Explain the need for normalization in datasets.
3. Compare Sigmoid and ReLU functions.
4. Discuss the role of gradient descent in training neural networks.
5. Explain Convolutional Neural Network (CNN).
6. Define padding and stride in convolutional neural networks.
7. Explain Recurrent Neural Network (RNN)
8. Discuss Beam search methodology.
9. Explain Support Vector Machine (SVM).
10. List any three applications of machine learning in real-world systems.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain the mathematical foundations required for machine learning including probability, statistics and linear algebra (7)  
b) Describe data preprocessing techniques such as normalization, data augmentation and handling different data distributions. (7)
12. a) Explain the different machine learning models. (7)  
b) Discuss convex optimization and hypothesis testing in machine learning models. (7)

**Module II**

13. a) Explain the structure of a multilayer neural network and the role of weights and bias. (7)  
b) Describe the backpropagation algorithm used for training neural networks. (4)
14. a) Explain the unstable gradient problem in deep neural networks. (7)  
b) Discuss regularization techniques such as dropout, batch normalization, L1 and L2 regularization (7)

**Module III**

15. a) Explain the architecture and working of Convolutional Neural Networks. (7)  
b) Describe convolution layer, pooling layer and flattening process in CNN. (7)
16. a) Explain the concept of  $1 \times 1$  convolution and Inception networks. (7)  
b) Discuss transfer learning and one-shot learning in deep learning. (7)

**Module IV**

17. a) Explain Recurrent Neural Networks and their applications in sequence learning. (7)  
b) Describe Long Short-Term Memory (LSTM). (7)
18. a) Explain reinforcement learning framework. (7)  
b) Illustrate reinforcement learning framework with the help of an example. (7)

**Module V**

19. a) Explain the working principle of Support Vector Machines and margin maximization. (10)  
b) Describe Bayesian learning and its role in machine learning. (4)
20. a) Discuss applications of machine learning in computer vision and speech processing. (7)  
b) Explain the significance of the ImageNet competition in the development of deep learning models. (7)

| B24EC4G32 | ROBOTICS | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|----------|---|---|---|---|--------|----------------------|
|           |          | 2 | 1 | 0 | 4 | 3      | 2024                 |

**Preamble**

This course offers fundamental concepts and terminology in Robotics.

**Prerequisites**

B24MA1T01: LINEAR ALGEBRA AND MULTIVARIABLE CALCULUS

B24EC3T02 : CONTROL SYSTEMS

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                                                                                                                                               |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Describe the basic components, structural configurations, and degrees of freedom (DOF) of robots. [Understand, Apply]                                                                         |
| <b>CO 2</b> | Apply forward and inverse kinematics for different types of robotic manipulators. Implement various types of controllers and explain their impact on robot motion control [Understand, Apply] |
| <b>CO 3</b> | Identify and compare different types of sensors and actuators used in robotic systems [Understand, Analyze]                                                                                   |
| <b>CO 4</b> | Describe the basics of robot cell layouts considering multiple robots and machine interfaces. [Understand]                                                                                    |
| <b>CO 5</b> | Describe the emerging trends in Robotics. [Understand]                                                                                                                                        |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> | 3    | 2    |      |      |      |      |      |      |      |       |       |
| <b>CO 2</b> | 3    | 3    |      | 2    |      |      |      |      |      |       |       |
| <b>CO 3</b> | 3    | 2    | 3    | 2    | 2    |      |      |      |      |       |       |
| <b>CO 4</b> | 3    | 3    | 3    | 2    | 3    |      |      |      |      |       |       |
| <b>CO 5</b> | 3    | 2    | 3    | 2    | 2    | 2    |      |      |      | 2     | 2     |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## SYLLABUS

### MODULE 1

**Fundamentals of Robotics:** : Definition and history of robotics. Applications of robotics in industry and service sectors. Robot Anatomy, Basic components, Structural configuration, Degrees of Freedom (DOF) and their significance, Work Volume and Workspace Analysis, Manipulator Kinematics, Position representation, Introduction to forward and inverse kinematics, Homogeneous transformations and their application in robot kinematics, D-H Notations, Formulating and solving kinematic equations.

### MODULE 2

**Control Systems for Robots:** Basic Control System Models, Robot Motions, Types of motions, Path planning and trajectory generation. Controllers.

### MODULE 3

**Actuation and Feedback Mechanisms:** Sensors, Actuators, Electric actuators, Power Transmission Devices, End Effectors, Types of grippers, Design considerations for grippers, Methods of Power and Control Signal Transmission:

### MODULE 4

**Robot Cell Layouts::** Design considerations for multiple robots and machine interfaces. Examples of typical robot cell layouts. Work Cell Control: Interlocks and safety mechanisms. Error detection and recovery strategies. Work Cell Controllers: Types and functions of work cell controllers. Integration with other control systems. Cycle Time Analysis: Techniques for analyzing and optimizing robot cycle times. Factors affecting cycle time and productivity.

### MODULE 5

**Industrial Applications** General considerations for material handling with robots, Material transfer applications, Pick and Place Operations, Industrial Robotics 4.0 and Smart Manufacturing, Internet of Things (IoT) in Robotics, Cloud Robotics, Medical and Surgical Robots, Autonomous Vehicles and Drones, Humanoid Robots, Space Robotics, Ethical and Social Implications of Robotics

### Text Books

1. John. J. Craig, Introduction to Robotics: Mechanics and Control, PHI, 2005.
2. Spong and Vidyasagar, Robot Dynamics and Control, John Wiley & Sons, 1990.
3. Mikell P. Groover, et al., Industrial Robotics – Technology, Programming and Applica-



tions, McGraw Hill, 2nd Edition, 2012

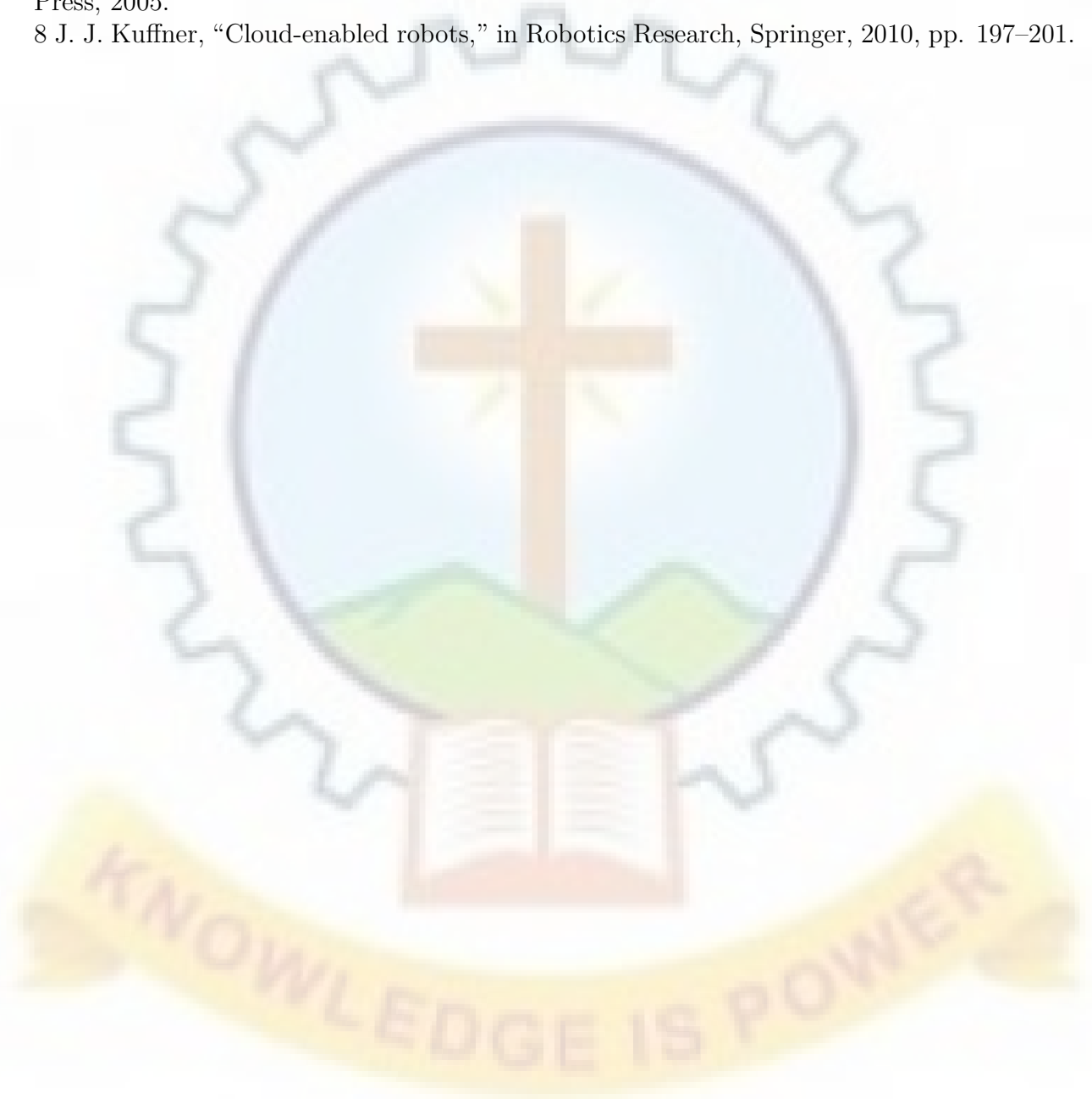
4. Saeed B. Niku, Introduction to Robotics: Analysis, Systems, Applications, John Wiley & Sons, 2nd Edition, 2011.

5. S.K. Saha, Introduction to Robotics, Tata McGraw Hill, 2nd Edition, 2014

6. Ashitava Ghosal, Robotics, Fundamental concepts and analysis, OXFORD University Press, 2006

7. T. R. Kurfess, Ed., Robotics and Automation Handbook. Boca Raton, FL, USA: CRC Press, 2005.

8 J. J. Kuffner, "Cloud-enabled robots," in Robotics Research, Springer, 2010, pp. 197–201.



**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                                                                                                                               | <b>No of Lecture/Tutorial Hours</b> |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                                                                                                                                            | <b>10</b>                           |
| 1.1       | Fundamentals of Robotics: Definition and history of robotics Applications of robotics in industry and service sectors.                                                                                                     | 1                                   |
| 1.2       | Robot Anatomy: Basic components: Links, joints, and end effectors.                                                                                                                                                         | 1                                   |
| 1.3       | Degrees of Freedom (DOF) and their significance.                                                                                                                                                                           | 1                                   |
| 1.4       | Configurations of Robots: Cartesian, Cylindrical, Spherical, Articulated, SCARA.                                                                                                                                           | 1                                   |
| 1.5       | Work Volume and Workspace Analysis: Definition and importance. Factors affecting workspace.                                                                                                                                | 1                                   |
| 1.6       | Manipulator Kinematics: Position representation.                                                                                                                                                                           | 1                                   |
| 1.7       | Introduction to forward and inverse kinematics. Homogeneous transformations and their application in robot kinematics.                                                                                                     | 2                                   |
| 1.8       | D-H Notations: Formulating and solving kinematic equations.                                                                                                                                                                | 2                                   |
|           | <b>Module 2</b>                                                                                                                                                                                                            | <b>5</b>                            |
| 2.1       | Control Systems for Robots : Basic Control System Models: Open-loop and closed-loop control. Block diagrams and transfer functions.                                                                                        | 1                                   |
| 2.2       | Robot Motions: Types of motions: Slew motion, joint-interpolated motion, and straight line motion.                                                                                                                         | 1                                   |
| 2.3       | Path planning and trajectory generation.                                                                                                                                                                                   | 1                                   |
| 2.4       | Controllers: On/off control. Proportional (P) control. Integral (I) control. Proportional plus integral (PI) control. Proportional plus derivative (PD) control. Proportional plus integral plus derivative (PID) control. | 2                                   |
|           | <b>Module 3</b>                                                                                                                                                                                                            | <b>7</b>                            |
| 3.1       | Actuation and Feedback Mechanisms:Sensors: Types of sensors: Position and velocity sensors.                                                                                                                                | 1                                   |
| 3.2       | Actuators: Electric actuators: DC motors, stepper motors, and servomotors. .                                                                                                                                               | 2                                   |
| 3.3       | Hydraulic actuators and Pneumatic actuators.                                                                                                                                                                               | 1                                   |
| 3.4       | Power Transmission Devices: Gears, belts, chains. Lead screws and ball screws.                                                                                                                                             | 1                                   |
| 3.5       | End Effectors: Types of grippers: Mechanical, vacuum, magnetic, Design considerations for grippers .                                                                                                                       | 1                                   |
| 3.6       | Methods of Power and Control Signal Transmission: Electrical, hydraulic, pneumatic transmission.                                                                                                                           | 1                                   |
|           | <b>Module 4</b>                                                                                                                                                                                                            | <b>8</b>                            |

|     |                                                                                                                                |                 |
|-----|--------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 4.1 | Robot Cell Layouts: Design considerations for multiple robots and machine interfaces. Examples of typical robot cell layouts.  | 2               |
| 4.2 | Work Cell Control: Interlocks and safety mechanisms. Error detection and recovery strategies.                                  | 2               |
| 4.3 | Work Cell Controllers: Types and functions of work cell controllers. Integration with other control systems.                   | 2               |
| 4.4 | Cycle Time Analysis: Techniques for analyzing and optimizing robot cycle times. Factors affecting cycle time and productivity. | 2               |
|     | <b>Module 5</b>                                                                                                                | <b>6</b>        |
| 5.1 | General considerations for material handling with robots, Material transfer applications.Pick and Place Operations.            | 2               |
| 5.2 | Industrial Robotics 4.0 and Smart Manufacturing,Internet of Things (IoT) in Robotics.                                          | 1               |
| 5.3 | Cloud Robotics,Medical and Surgical Robots .                                                                                   | 1               |
| 5.4 | Autonomous Vehicles and Drones,Humanoid Robots (e.g., ASIMO)                                                                   | 1               |
| 5.5 | Space Robotics ,Ethical and Social Implications of Robotics.                                                                   | 1               |
|     | <b>Total Hours</b>                                                                                                             | <b>36 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the history of robotics, basic definitions, classification of robots, and their applications in industrial and service sectors
2. Describe robot anatomy (links, joints, end effectors), structural configurations (e.g., Cartesian, cylindrical, spherical, SCARA, articulated), Degrees of Freedom (DOF), workspace types/analysis, and basic manipulator kinematics concepts (positions, orientations, transformations).

#### Course Outcome 2 (CO 2):

1. Formulate and solve forward kinematics problems for robotic manipulators using homogeneous transformation matrices and Denavit-Hartenberg (D-H) parameters to determine end-effector position and orientation from joint variables.
2. Formulate and solve inverse kinematics equations using analytical or geometric methods (with D-H parameters) to determine required joint variables for a desired end-effector pose, including handling multiple solutions and singularities where applicable.

**Course Outcome 3 (CO 3):**

1. Analyze robot control system models (e.g., open-loop vs. closed-loop, PID control, joint-space vs. task-space control) and classify types of robot motions
2. Implement basic path planning and trajectory generation techniques using suitable controllers for smooth and accurate robot motion.

**Course Outcome 4 (CO 4):**

1. Design and analyze robot cell layouts considering multiple robots, machine interfaces, safety interlocks, and error detection mechanisms to ensure efficient and safe industrial operation
2. Evaluate work cell controllers and optimize robot cycle time by analyzing control integration, productivity factors, and performance parameters.

**Course Outcome 5 (CO 5):**

1. Evaluate industrial robot cell layouts cycle time optimization techniques and safety mechanisms
2. Analyze modern trends such as IoT-enabled robotics, cloud robotics, medical robots (e.g., surgical systems), autonomous mobile systems, space robotics, and discuss their ethical implications (e.g., job displacement, privacy), social impacts (e.g., human-robot collaboration, accessibility), and future challenges.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 2**

**Reg.No.: .....**

**Name: .....**

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2028**

**Course Code: B24EC4G32**

**Course Name: ROBOTICS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. What is Degrees of Freedom (DOF) in robotics? State its significance.
2. List three basic components of a robot and explain the role of one of them in robot anatomy.
3. What are the different types of robot motions?
4. Define path planning and trajectory generation. State one difference between them.
5. Compare pneumatic and hydraulic actuators used in robotic control.
6. What are the common methods used for power and control signal transmission in robotic systems?
7. Define robot cell layout.
8. List any three factors affecting robot cycle time and productivity.
9. List the main techniques used in collaborative operations by cobots.
10. Which are the industrial applications of robots in material handling and assembly?

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain the structural configurations of robots, including Cartesian, cylindrical, and spherical types. (7)  
b) Describe the integral components which are integrated together to form a robot. (7)
12. a) Describe forward kinematics in manipulators. Using homogeneous transformations, derive the position of the end-effector for a 2-DOF planar robot arm. (7)  
b) What is inverse kinematics? Explain its importance in robot control. (7)

**Module II**

13. a) Explain the basic components of a closed-loop control system in robotics with a neat block diagram. Discuss its advantages over an open-loop system. (7)  
b) Explain different types of controllers used in robotic control systems such as P, PI, and PID controllers. Compare their performance characteristics. (7)
14. a) Explain the concept of path planning in robotics. Discuss different path planning methods used in robotic systems. (7)  
b) A robotic joint is required to move from one position to another smoothly. Explain how trajectory planning ensures smooth motion with minimum jerk and controlled velocity. (7)

**Module III**

15. a) Explain the parameters to be considered while selecting an actuator? (7)  
b) Explain construction and working of a brushless DC motor. (7)
16. a) Describe different types of end effectors used in robotics. (7)  
b) Explain the methods of power transmission in robotic systems. Compare electrical, hydraulic, and pneumatic power transmission methods. (7)

**Module IV**

17. a) Describe different types of typical robot cell layouts with suitable examples (7)  
b) Describe the types and functions of work cell controllers.. (7)
18. a) Explain cycle time analysis in robotic systems (7)  
b) Discuss the factors affecting robot cycle time and overall productivity. (7)

**Module V**

19. a) Elaborate on the application of artificial intelligence in robotics. (7)



- b) Explain the terms biped locomotion and imitation learning used in humanoid robots. (7)
- 20. a) Comment on the significant role played by robotics in different areas for realizing Industry 4.0. (7)
- b) Explain different safety approaches to assure safe cooperation of human workers and industrial robots. (7)



| B24EC4G33 | REAL TIME<br>OPERATING<br>SYSTEMS | L | T | P | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|-----------------------------------|---|---|---|---|--------|-------------------------|
|           |                                   | 2 | 1 | 0 | 4 | 3      | 2024                    |

### Preamble

This introductory course offers a comprehensive overview of Real-Time Operating Systems (RTOS), beginning with the basic concepts of operating systems. It emphasizes core real-time principles, scheduling techniques, and system design aspects applicable to embedded and real-time systems.

### Prerequisites

Nil

### Course Outcomes

After the completion of the course, the student will be able to:

|      |                                                                                                                                                                                                          |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Understand the basic concepts, structure, and development of operating systems, including how processes are managed and the different types of operating systems. [Understand]                           |
| CO 2 | Compare different process and thread scheduling algorithms, as well as multi-threading models, to determine which are best suited for various system needs and requirements. [Analyze]                   |
| CO 3 | Explain the requirements and mechanisms of real-time systems—such as task management, synchronization, communication, and interrupt handling—and apply them across multidisciplinary areas. [Understand] |
| CO 4 | Examine real-time scheduling algorithms and task constraints to determine whether a real-time system is feasible and operates correctly. [Evaluate]                                                      |
| CO 5 | Evaluate practical aspects of real-time system design, including memory and I/O management and the suitability of commercial RTOS solutions for real life applications. [Evaluate]                       |

### Mapping of Course Outcomes With Program Outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|------|------|------|------|------|------|------|------|------|------|-------|-------|
| CO 1 | 3    | 2    | 1    | 1    |      |      |      | 1    | 1    | 1     | 1     |
| CO 2 | 2    | 3    | 2    | 2    |      |      |      | 1    | 1    | 1     | 1     |
| CO 3 | 2    | 3    | 2    | 3    | 1    | 1    |      | 1    | 1    | 1     | 1     |
| CO 4 | 2    | 3    | 3    | 3    | 1    | 1    |      | 1    | 1    | 1     | 1     |
| CO 5 | 2    | 3    | 2    | 3    | 2    | 2    | 1    | 1    | 1    | 1     | 1     |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         |                       |                 |                                    |
| Understand       | 30                    | 30              | 30                                 |
| Apply            | 50                    | 50              | 50                                 |
| Analyse          | 10                    | 10              | 10                                 |
| Evaluate         | 10                    | 10              | 10                                 |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions

from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.



## SYLLABUS

### MODULE 1

**Introduction:** Introduction to Operating Systems, Operating system: Definition, Objectives and Functions. Role of operating systems in multi-disciplinary engineering systems. Evolution of operating systems, Types of systems, OS Architecture - Types Basic OS concepts: Processes, Process Control Block Process states and state transitions, Operations on processes, Context switching

### MODULE 2

**Scheduling Algorithms:** Scheduling algorithms – Need for scheduling algorithm, Process scheduling, Levels of scheduling algorithms, Design goals. Types – Pre-emptive and Non-preemptive algorithms Types of algorithms – First Come First Serve, Shortest Job First, Smallest Remaining Time First, Priority Based, Round Robin – Simple numerical examples. Multilevel Queue and Multilevel Feedback Queue Scheduling, multiprocessor scheduling. Thread: Structure. User and kernel level threads, multi-threading models.

### MODULE 3

**Introduction to real time systems:** General-purpose OS and Real-Time OS - comparison. Definition and characteristics of real-time systems. Classification of real-time systems: Hard, Soft real-time systems Real Time Operating Systems: Structure, components and characteristics of Real Time Systems. Real-time performance metrics. Real-time system applications across multidisciplinary areas - Industrial automation and robotics, Power system monitoring and protection, Traffic control and smart infrastructure, Process control systems. Task: Task states, Task synchronization -Semaphores- types, Inter task communication mechanisms.

### MODULE 4

**Real time scheduling algorithms:** Real-time tasks and task models, Task constraints – timing, precedence and resource constraints. Scheduling criteria and feasibility. Task scheduling: Aperiodic task scheduling: EDD, EDF, LDF, EDF with precedence constraints. Periodic task scheduling: Rate monotonic and Deadline monotonic.

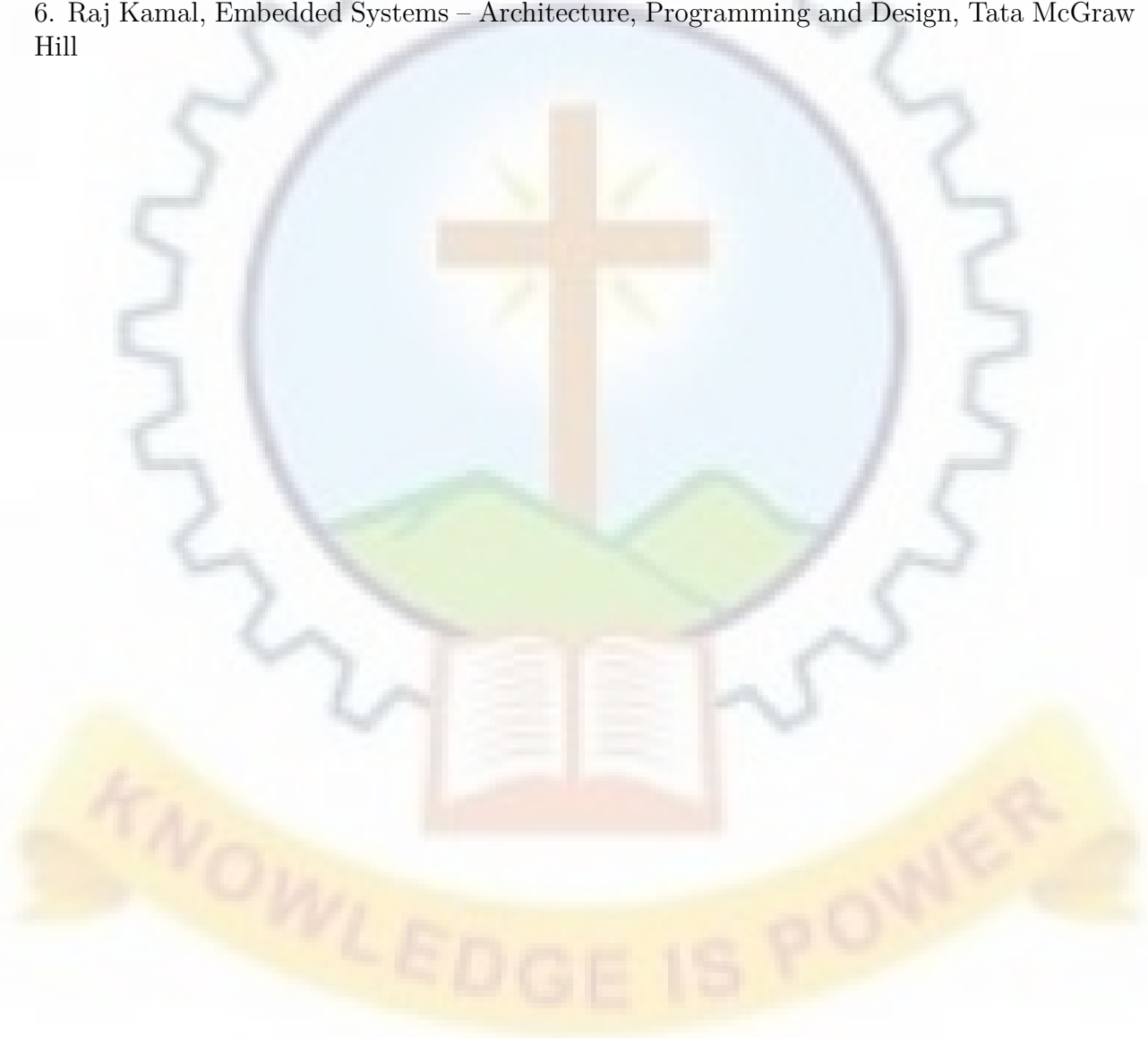
### MODULE 5

**Practical real time systems:** Memory and I/O management in real time systems – Port mapped, Memory mapped I/O, DMA. POSIX standard, Features of some commercial real

time operating systems Free RTOS, MicroC/OS-II, PSOS, VRTX, RT Linux- Features and applications. RTOS control system used in real life applications - in adaptive cruise control, traffic light management.

**Text Books**

1. Abraham Silberschatz, Operating System Principles, Wiley India
2. William Stallings, Operating systems- Internals and design principles, Prentice Hall
3. Qing Li, Real-Time Concepts for Embedded Systems, CMP Books
4. Andrew S. Tanenbaum, Modern Operating Systems, Pearson
5. Rajib Mall, Real-Time Systems: Theory and Practice, Pearson
6. Raj Kamal, Embedded Systems – Architecture, Programming and Design, Tata McGraw Hill





**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                                                                                                                                  | <b>No of Lecture/Tutorial Hours</b> |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                                                                                                                               | <b>7</b>                            |
| 1.1       | Introduction to Operating Systems, Operating system: Definition, Objectives and Functions.                                                                                                                    | 1                                   |
| 1.2       | Role of operating systems in multi-disciplinary engineering systems.                                                                                                                                          | 1                                   |
| 1.3       | Evolution of operating systems, Types of systems, OS Architecture - Types.                                                                                                                                    | 2                                   |
| 1.4       | Types of systems: Basic OS concepts: Processes, Process Control Block Process states and state transitions.                                                                                                   | 2                                   |
| 1.5       | Operations on processes, Context switching.                                                                                                                                                                   | 1                                   |
|           | <b>Module 2</b>                                                                                                                                                                                               | <b>7</b>                            |
| 2.1       | Scheduling algorithms – Need for scheduling algorithm, Process scheduling, Levels of scheduling algorithms, Design goals.                                                                                     | 1                                   |
| 2.2       | Types – Pre-emptive and Non-preemptive algorithms.                                                                                                                                                            | 1                                   |
| 2.3       | Types of algorithms – First Come First Serve, Shortest Job First.                                                                                                                                             | 1                                   |
| 2.4       | Smallest Remaining Time First, Priority Based.                                                                                                                                                                | 1                                   |
| 2.5       | Round Robin.                                                                                                                                                                                                  | 1                                   |
| 2.6       | Multilevel Queue and Multilevel Feedback Queue Scheduling.                                                                                                                                                    | 1                                   |
| 2.7       | Multiprocessor scheduling, Thread: Structure, User and kernel level threads, multi-threading models                                                                                                           | 1                                   |
|           | <b>Module 3</b>                                                                                                                                                                                               | <b>9</b>                            |
| 3.1       | General-purpose OS and Real-Time OS - comparison. Definition and characteristics of real-time systems.                                                                                                        | 1                                   |
| 3.2       | Classification of real-time systems: Hard, Soft real-time systems.                                                                                                                                            | 1                                   |
| 3.3       | Real Time Operating Systems: Structure, components and characteristics of Real Time Systems. Real-time performance metrics.                                                                                   | 1                                   |
| 3.4       | Real-time system applications across multidisciplinary areas - Industrial automation and robotics, Power system monitoring and protection, Traffic control and smart infrastructure, Process control systems. | 2                                   |
| 3.5       | Task states                                                                                                                                                                                                   | 1                                   |
| 3.6       | Task synchronization -Semaphores- types.                                                                                                                                                                      | 2                                   |
| 3.7       | Inter task communication mechanisms.                                                                                                                                                                          | 1                                   |
|           | <b>Module 4</b>                                                                                                                                                                                               | <b>7</b>                            |
| 4.1       | Real-time tasks and task models, Task constraints – timing, precedence and resource constraints.                                                                                                              | 1                                   |

|     |                                                                                                            |                 |
|-----|------------------------------------------------------------------------------------------------------------|-----------------|
| 4.2 | Scheduling criteria and feasibility.                                                                       | 1               |
| 4.3 | Task scheduling: Aperiodic task scheduling: EDD.                                                           | 1               |
| 4.4 | EDF, LDF.                                                                                                  | 1               |
| 4.5 | EDF with precedence constraints.                                                                           | 1               |
| 4.6 | Periodic task scheduling: Rate monotonic and Deadline monotonic.                                           | 2               |
|     | <b>Module 5</b>                                                                                            | <b>5</b>        |
| 5.1 | Memory and I/O management in real time systems – Port mapped, Memory mapped I/O, DMA.                      | 1               |
| 5.2 | POSIX standard, Features of some commercial real time operating systems Free RTOS, MicroC/OS-II, PSOS.     | 1               |
| 5.3 | PSOS, VRTX, RT Linux- Features and applications.                                                           | 1               |
| 5.4 | RTOS control system used in real life applications - in adaptive cruise control, traffic light management. | 2               |
|     | <b>Total Hours</b>                                                                                         | <b>35 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Describe the evolution process of operating system from primitive to modern systems.
2. Describe the functionalities of an operating system as a resource manager.

#### Course Outcome 2 (CO 2):

1. Compute the average waiting time and average turnaround time according to Round Robin Scheduling algorithm with a time quantum of 2 millisecond. There are 5 process to be scheduled P1, P2, P3, P4, P5 with estimated execution time 1,4,2,6,3 milliseconds respectively.
2. Differentiate between a process and a thread.

#### Course Outcome 3 (CO 3):

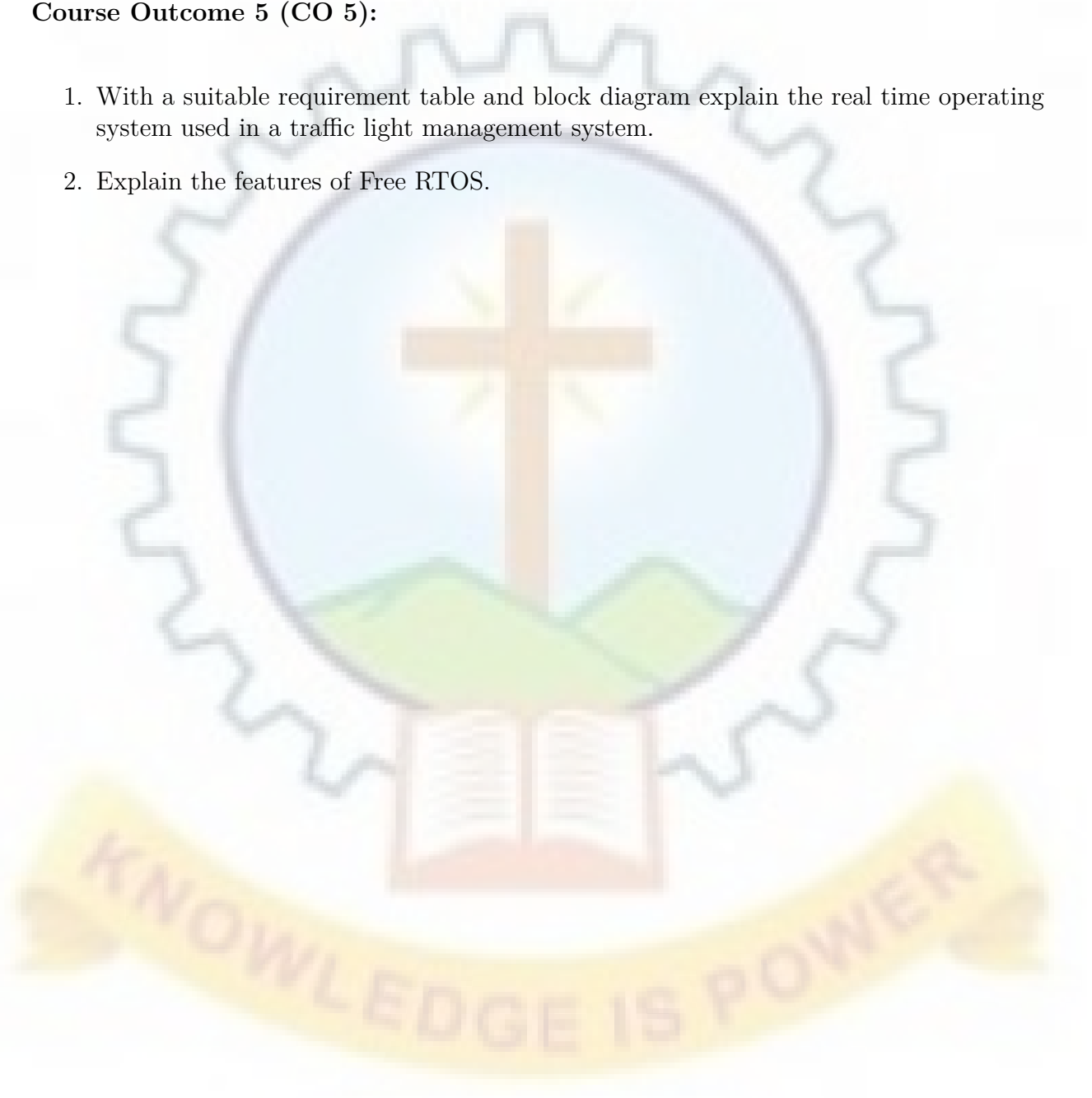
1. Explain the concept of semaphores. Also explain different types of semaphores.
2. Differentiate between a hard real time system and a soft real time system with an example.

**Course Outcome 4 (CO 4):**

1. Differentiate between aperiodic and periodic task scheduling.
2. Explain the timing constraints of a Real Time Operating System.

**Course Outcome 5 (CO 5):**

1. With a suitable requirement table and block diagram explain the real time operating system used in a traffic light management system.
2. Explain the features of Free RTOS.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2028**

**Course Code: B24EC4G33**

**Course Name: REAL TIME OPERATING SYSTEMS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Differentiate between user mode and kernel mode.
2. Explain the concept of context switching.
3. Differentiate between preemptive and non-preemptive scheduling.
4. Explain the features of multi-level feedback queue scheduling.
5. Sketch and explain the structure of RTOS.
6. Differentiate between hard and soft real time systems with examples.
7. Differentiate between periodic and aperiodic task.
8. What is meant by feasibility of scheduling criteria.
9. Differentiate between port mapped and memory mapped I/O.
10. List any 3 applications of Free RTOS.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Explain the 5-state process model and state transition with diagram. (9)  
b) Differentiate between a batch system and an user interactive system. (5)
12. a) Draw the structure of a process control block in memory. Explain the significance of process control block. (7)  
b) Compare Monolithic and Layered architecture of operating systems. (7)

### Module II

13. a) Draw the Gantt chart for the round robin scheduling algorithm and shortest job first algorithm. Find the average waiting time and turn-around time. Determine which algorithm will be most suitable for the given set of process. Assume time slice of 2ms. (7)

| Process | Burst Time (ms) |
|---------|-----------------|
| P1      | 10              |
| P2      | 4               |
| P3      | 2               |
| P4      | 1               |
| P5      | 5               |

- b) Explain different goals to be taken into consideration while designing a scheduling algorithm. (7)
14. a) With the help of example, differentiate between First Come First Serve and Shortest Job First scheduling algorithms. (9)  
b) Differentiate between user level and kernel level threads (5)

### Module III

15. a) Explain semaphores and its significance. Explain different types of semaphores with its state transition diagram. (9)  
b) Explain various states of a task. (5)
16. a) Draw the structure of a Real Time Operating System and explain with an example. (7)  
b) Explain the concept of mutual exclusion. (7)

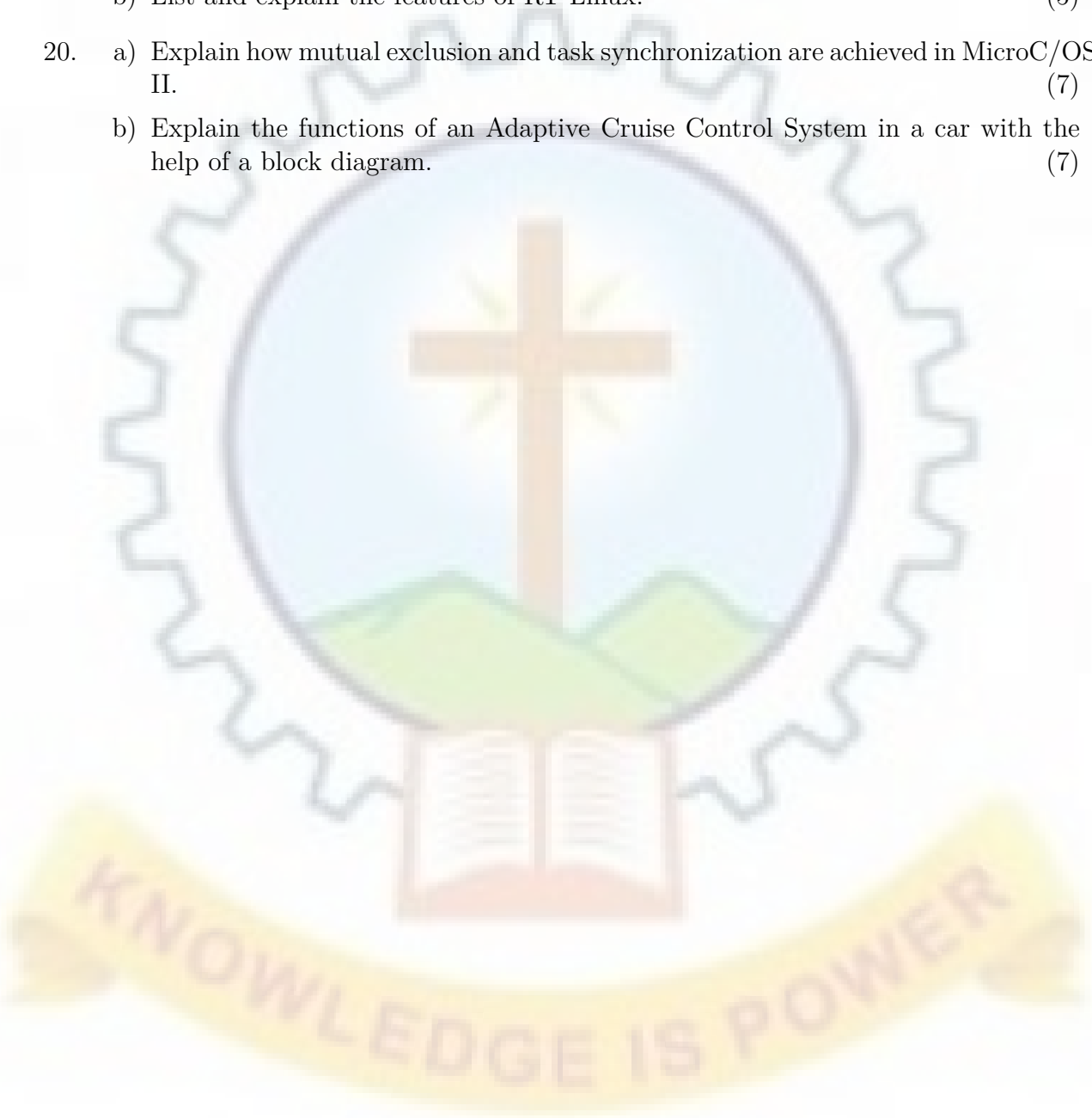
### Module IV

17. Explain Rate Monotonic and Deadline Monotonic scheduling algorithms with an example. (14)

18. Explain Earliest Deadline First algorithm with an example. Compare it with Earliest Due Date algorithm. (14)

**Module V**

19. a) Differentiate between dynamic and static memory partitioning. (7)  
b) List and explain the features of RT Linux. (5)
20. a) Explain how mutual exclusion and task synchronization are achieved in MicroC/OS-II. (7)  
b) Explain the functions of an Adaptive Cruise Control System in a car with the help of a block diagram. (7)





| <b>B24EC4G34</b> | <b>MECHATRONICS</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF INTRODUCTION</b> |
|------------------|---------------------|----------|----------|----------|----------|---------------|-----------------------------|
|                  |                     | 2        | 1        | 0        | 4        |               |                             |

**Preamble**

The course on Mechatronics is designed to provide a comprehensive understanding of the integration of mechanical, electrical, electronic, and control engineering systems for the development of intelligent products and processes. It introduces students to the rapidly emerging, multi-disciplinary, and exciting field of Mechatronics.

**Prerequisites**

B24ES1T02 BASICS OF ELECTRICAL & ELECTRONICS ENGINEERING  
B24EC3T02 CONTROL SYSTEMS

**Course Outcomes**

After the successful completion of the course the student will be able to:

|             |                                                                                                                                                                                                                                        |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Explain the fundamental concepts of mechatronics and to apply electrical and mechanical analogies to model physical systems. [Understand,Apply]                                                                                        |
| <b>CO 2</b> | Explain the principles, characteristics, and classification of sensors and transducers used in mechatronic systems. (Understand)                                                                                                       |
| <b>CO 3</b> | Explain the construction, working principles, and mathematical modeling of AC and DC also to explain the architecture, features, and operation of PLC systems and develop basic PLC programs for automation tasks. [Understand, Apply] |
| <b>CO 4</b> | Explain the concepts of continuous and discrete control systems and to examine and interpret real-world case studies of mechatronic systems [Understand,Apply]                                                                         |
| <b>CO 5</b> | Understand the structure and functioning of basic robotic systems and apply concepts of robotic manipulator kinematics for motion analysis.[Understand]                                                                                |

**Mapping of Course Outcomes With Program Outcomes**

|             | <b>PO 1</b> | <b>PO 2</b> | <b>PO 3</b> | <b>PO 4</b> | <b>PO 5</b> | <b>PO 6</b> | <b>PO 7</b> | <b>PO 8</b> | <b>PO 9</b> | <b>PO 10</b> | <b>PO 11</b> |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|
| <b>CO 1</b> | 3           | 2           | 1           | 2           | 2           |             |             |             |             |              | 1            |
| <b>CO 2</b> | 3           | 3           | 2           | 2           | 2           |             |             |             |             |              | 1            |
| <b>CO 3</b> | 3           | 3           | 3           | 2           | 3           |             |             |             |             |              | 1            |
| <b>CO 4</b> | 3           | 3           | 3           | 3           | 2           |             |             |             |             |              | 2            |
| <b>CO 5</b> | 3           | 2           | 3           | 2           | 3           |             |             |             |             |              | 2            |

### Assessment Pattern

| Bloom's Category | Continuous Assessment |                    | End Semester Examination<br>(% Marks) |
|------------------|-----------------------|--------------------|---------------------------------------|
|                  | Test 1<br>(%Marks)    | Test 2<br>(%Marks) |                                       |
| Remember         |                       |                    |                                       |
| Understand       | 80                    | 80                 | 80                                    |
| Apply            | 20                    | 20                 | 20                                    |
| Analyse          |                       |                    |                                       |
| Evaluate         |                       |                    |                                       |
| Create           |                       |                    |                                       |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## **SYLLABUS**

### **MODULE 1**

**Introduction to Mechatronics :** Mechatronics key elements, Mechatronics design process. Modeling and Simulation of Physical System -Simulation and Block Diagrams, Analogies and Impedance Diagrams, Electrical Systems, Mechanical Translation systems, Mechanical rotational system, Electromechanical coupling, Fluid systems.

### **MODULE 2**

**Sensors and Transducers:** Introduction to Sensors and transducers, Sensors for motion (Potentiometric, Inductive, Capacitive) and position Measurement (Hall Effect transducer) force, torque, and Tactile sensors, flow sensors-Solid flow and Liquid flow (Differential pressure measurement, Ultrasonic flow transducer, Turbine flowmeter) , Temperature – sensing devices, Ultrasonic sensors, range sensors (Basic triangulation principle only), active vibration control using magnetostrictive transducers, Fiber optic devices in mechatronics.

### **MODULE 3**

**Actuating Devices-** Direct current motor-Mathematical model, Brushless dc motor, AC Motor. Permanent magnet stepper motor-Modelling Approach, Drive equations and block diagram model, Motor equations and block diagram model. Fluid power actuation-Control Systems in fluid power and Fluid power actuators. Fluid power design elements-Fluid power energy input devices, Energy modulation devices, Energy Output Devices, Control Modes of Fluid Power Circuits. Programmable Controllers-PLC system overview, Features of PLC, Basics of PLC programming.

### **MODULE 4**

**Closed Loop controllers** Continuous and discrete processes, control modes, two step mode, proportional mode, derivative control, integral control, PID controller, digital controllers, control system performance, controller tuning, velocity control and Adaptive control .Advanced applications in mechatronics -Sensors for condition monitoring, Mechatronic control in automated Manufacturing, Fuzzy logic applications in Mechatronics, Micro sensors in mechatronics. Case studies of Mechatronics systems: Automatic car park barrier system, automobile engine management system.

### **MODULE 5**

**Robotic systems-**Basic robotic systems, Types of robot, Robotic arm terminology, Robotic arm configuration, Robotic manipulator kinematics, Robotic arm positioning concepts, Robotic arm path planning. Robotic vision system - Image acquisition: CCD and charge injection device (CID) cameras. Image processing techniques: histogram processing: sliding, stretching, WD and thresholding. Case studies: Case study 1: A PC-based computer numerically controlled (CNC) drilling machine Case study 2: A robotic arm

### Text Books

- 1.Devdas Shetty and Richard.A.Kolk, “Mechatronics system design”, Thomson Asia Pte. Ltd. Second reprint, 2001.
2. W.Bolton, “Mechatronics”, Pearson Education Asia, Third Indian Reprint 2001.
- 3.Godfrey C. Onwubolu,“Mechatronics Principles and Applications“,Elsevier,First print 2005.
- 4.Introduction to Mechatronics and Measurement Systems – David G. Alciatore and Michael B. Histan, McGraw-Hill
- 5.Machine Vision – Rafael C. Gonzalez and Richard E. Woods, Pearson.

### COURSE CONTENTS AND LECTURE SCHEDULE

| No  | Topic                                                                                                                                                | No of Lecture/Tutorial Hours |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
|     | <b>Module 1</b>                                                                                                                                      | <b>7</b>                     |
| 1.1 | Introduction to Mechatronics: Mechatronics key elements, Mechatronics design process.                                                                | 1                            |
| 1.2 | Modeling and Simulation of Physical System -Simulation and Block Diagrams, Analogies and Impedance Diagrams.                                         | 1                            |
| 1.3 | Electrical Systems,                                                                                                                                  | 1                            |
| 1.4 | Mechanical Translation systems                                                                                                                       | 1                            |
| 1.5 | Mechanical rotational system                                                                                                                         | 1                            |
| 1.6 | Electromechanical coupling                                                                                                                           | 1                            |
| 1.7 | Fluid systems                                                                                                                                        | 1                            |
|     | <b>Module 2</b>                                                                                                                                      | <b>7</b>                     |
| 2.1 | Introduction to Sensors and transducers, Sensors for motion(Potentiometric,Inductive,Capacitive) and position Measurement(Hall Effect transducer)    | 2                            |
| 2.2 | Force, torque, and Tactile sensors, flow sensors                                                                                                     | 2                            |
| 2.3 | Solid flow and Liquid flow(Differential pressure measurement,Ultrasonic flow transducer,Turbine flowmeter)                                           | 1                            |
| 2.4 | Temperature – sensing devices, Ultrasonic sensors,                                                                                                   | 1                            |
| 2.5 | Range sensors(Basic triangulation principle only), active vibration control using magnetostrictive transducers, Fiber optic devices in mechatronics. | 2                            |
|     | <b>Module 3</b>                                                                                                                                      | <b>8</b>                     |
| 3.1 | Direct current motor-Mathematical model,Brushless dc motor,AC Motor.                                                                                 | 1                            |
| 3.2 | Permanent magnet stepper motor-Modelling Approach,Drive equations and block diagram model,Motor equations and block diagram model                    | 2                            |
| 3.3 | Fluid power actuation-Control Systems in fluid power and Fluid power actuators.                                                                      | 1                            |

|     |                                                                                                                                                                                                   |                 |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 3.4 | Fluid power design elements-Fluid power energy input devices,Energy modulation devices,Energy Output Devices,Control Modes of Fluid Power Circuits.                                               | 2               |
| 3.5 | Programmable Controllers-PLC system overview,Features of PLC,Basics of PLC programming.                                                                                                           | 2               |
|     | <b>Module 4</b>                                                                                                                                                                                   | <b>9</b>        |
| 4.1 | Closed Loop controllers Continuous and discrete processes, control modes, two step mode, proportional mode, derivative control, integral control                                                  | 2               |
| 4.2 | PID controller, digital controllers, control system performance, controller tuning, velocity control and Adaptive control .                                                                       | 2               |
| 4.3 | Advanced applications in mechatronics -Sensors for condition monitoring, Mechatronic control in automated Manufacturing, Fuzzy logic applications in Mechatronics, Micro sensors in mechatronics. | 3               |
| 4.4 | Case studies of Mechatronics systems:Automatic car park barrier system, Automobile engine management system.                                                                                      | 2               |
|     | <b>Module 5</b>                                                                                                                                                                                   | <b>7</b>        |
| 5.1 | Robotic systems-Basic robotic systems,Types of robot,Robotic arm terminology,Robotic arm configuration                                                                                            | 2               |
| 5.2 | Robotic manipulator kinematics,Robotic arm positioning concepts,Robotic arm path planning.                                                                                                        | 2               |
| 5.3 | Robotic vision system - Image acquisition:CCD and charge injection device (CID) cameras.                                                                                                          | 1               |
| 5.4 | Image processing techniques: histogram processing: sliding, stretching, WD and thresholding.                                                                                                      | 1               |
| 5.5 | MIMO in 5G and beyond (6G trends)Case studies:Case study 1:A PC-based computer numerically controlled (CNC) drilling machine Case study 2: A robotic arm                                          | 2               |
|     | <b>Total Hours</b>                                                                                                                                                                                | <b>38 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the key elements of a mechatronic system with a neat diagram.
2. Compare force-voltage and force-current analogies.
3. Model a mechanical rotational system using electrical analogies.

#### Course Outcome 2 (CO 2):



1. Classify sensors based on their function and application.
2. Explain the working principle of capacitive sensors.
3. Describe the principle of ultrasonic flow measurement.

**Course Outcome 3 (CO 3):**

1. Explain the working principle of a DC motor.
2. Explain fluid power actuators with examples.
3. Explain the architecture of a PLC system.

**Course Outcome 4 (CO 4):**

1. Explain the concept of closed-loop control systems with a block diagram.
2. Differentiate between continuous and discrete control systems.
3. Describe the role of sensors in condition monitoring.

**Course Outcome 5 (CO 5):**

1. Explain different types of robotic configurations.
2. Describe histogram processing techniques (sliding, stretching).
3. Describe robotic arm positioning concepts.



**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 2**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2028**

**Course Code: B24EC4G34**

**Course Name: MECHATRONICS**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. Derive the mathematical model of a simple mechanical system.
2. Define mechatronics and list its key elements.
3. Define sensor and transducer.
4. Define tactile sensor.
5. Describe the features and advantages of PLCs in automation.
6. Define an actuator.
7. What is a PID controller?
8. Describe the role of sensors in condition monitoring.
9. Define degree of freedom (DOF).
10. Define thresholding in image processing.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. a) Derive the mathematical model of a mass-spring-damper system and represent it using a block diagram. (7)  
b) Model an electromechanical system and explain the coupling between electrical and mechanical domains. (7)
12. a) Design a mechatronic system for a real-life application and explain its key elements and modeling approach. (7)  
b) Analyze the advantages of system modeling and simulation in mechatronics design. (7)

**Module II**

13. a) Compare potentiometric, inductive, and capacitive sensors based on working principle and applications. (8)  
b) Explain the working principles of force, torque, and tactile sensors with examples. (6)
14. a) Describe magnetostrictive transducers and their role in active vibration control. (7)  
b) Explain the use of fiber optic sensors in mechatronics and their advantages. (7)

**Module III**

15. a) Derive the mathematical model of a DC motor and represent it using a block diagram. (7)  
b) Develop the drive equations of a stepper motor and explain its block diagram model. (7)
16. a) Explain energy input, modulation, and output devices in fluid power systems. (7)  
b) Develop a basic PLC ladder program for a simple control application, motor ON/OFF control. (7)

**Module IV**

17. a) Analyze the performance of a system with proportional, integral, and derivative control actions. (8)  
b) Compare continuous and digital (discrete) controllers with suitable examples. (6)
18. a) Analyze an automated manufacturing system based on mechatronic control. (7)  
b) Explain the working of an automatic car park barrier system as a mechatronic system. (7)

**Module V**

19. a) Explain forward kinematics of a robotic manipulator with an example. (7)  
b) Compare different robotic arm configurations based on structure and applications. (7)
20. a) Discuss image processing techniques such as thresholding and windowing. (7)  
b) Analyze the working of a robotic vision system. (7)

| B24EC4G35 | ENTREPRENEURSHIP | L | T | P | S | CREDIT | YEAR OF INTRODUCTION |
|-----------|------------------|---|---|---|---|--------|----------------------|
|           |                  | 2 | 1 | 0 | 4 |        | 2024                 |

**Preamble**

This course aims to understand the knowledge of entrepreneurship and apply in the organization.

**Prerequisites**

B24HU2T02 : Entrepreneurship and management skills for engineers

**Course Outcomes**

After the completion of the course, the student will be able to:

|             |                                                                            |
|-------------|----------------------------------------------------------------------------|
| <b>CO 1</b> | Discuss the fundamental concepts of entrepreneurship.[Understand]          |
| <b>CO 2</b> | Understand entrepreneurial motivation and motivation theories.[Understand] |
| <b>CO 3</b> | Analyze types of enterprises and ownership structure.[Apply]               |
| <b>CO 4</b> | Apply project evaluation methods.[Apply]                                   |
| <b>CO 5</b> | Evaluate enterprise financial strength.[Understand,Apply]                  |

**Mapping of Course Outcomes With Program Outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|
| <b>CO 1</b> |      |      |      |      |      |      |      |      | 1    | 1     |       |
| <b>CO 2</b> |      |      |      |      |      | 1    |      | 1    |      |       |       |
| <b>CO 3</b> |      |      |      |      |      |      |      | 1    |      |       |       |
| <b>CO 4</b> | 2    |      | 1    |      | 2    |      |      |      | 1    | 3     |       |
| <b>CO 5</b> | 2    |      | 1    |      | 2    |      |      |      | 1    | 3     |       |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment |                 | End Semester Examination (% Marks) |
|------------------|-----------------------|-----------------|------------------------------------|
|                  | Test 1 (%Marks)       | Test 2 (%Marks) |                                    |
| Remember         | 20                    | 20              | 20                                 |
| Understand       | 40                    | 40              | 40                                 |
| Apply            | 40                    | 40              | 40                                 |
| Analyse          |                       |                 |                                    |
| Evaluate         |                       |                 |                                    |
| Create           |                       |                 |                                    |

### Mark Distribution

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|-------------|-----------|-----------|--------------|
| 150         | 50        | 100       | 3 hours      |

### Continuous Internal Evaluation Pattern

|                                        |          |
|----------------------------------------|----------|
| Attendance                             | 10 marks |
| Continuous Assessment Test (2 numbers) | 25 marks |
| Assignment/Class work                  | 10 marks |
| Self Study                             | 5 marks  |

### End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-division.

## **SYLLABUS**

### **MODULE 1**

**Entrepreneurship:** definition, requirements to be an entrepreneur, entrepreneur and intrapreneur, entrepreneur and manager, growth of entrepreneurship in India, women entrepreneurship, rural and urban entrepreneurship. **Entrepreneurial Motivation:** motivating factors, motivation theories-Maslow's need hierarchy theory, McClelland's acquired need theory, government's policy actions towards entrepreneurial motivation, entrepreneurship development programmes.

### **MODULE 2**

**Types of Enterprises and Ownership Structure:** small scale, medium scale and large scale enterprises, role of small enterprises in economic development; proprietorship, partnership, limited companies and co-operatives: their formation, capital structure and source of finance.

### **MODULE 3**

**Institutional Support and Policies:** Institutional support towards the development of entrepreneurship in India, technical consultancy organizations, Government programs, policies, incentive and institutional networking for enterprise setting, women entrepreneurship development in India, promotional schemes.

### **MODULE 4**

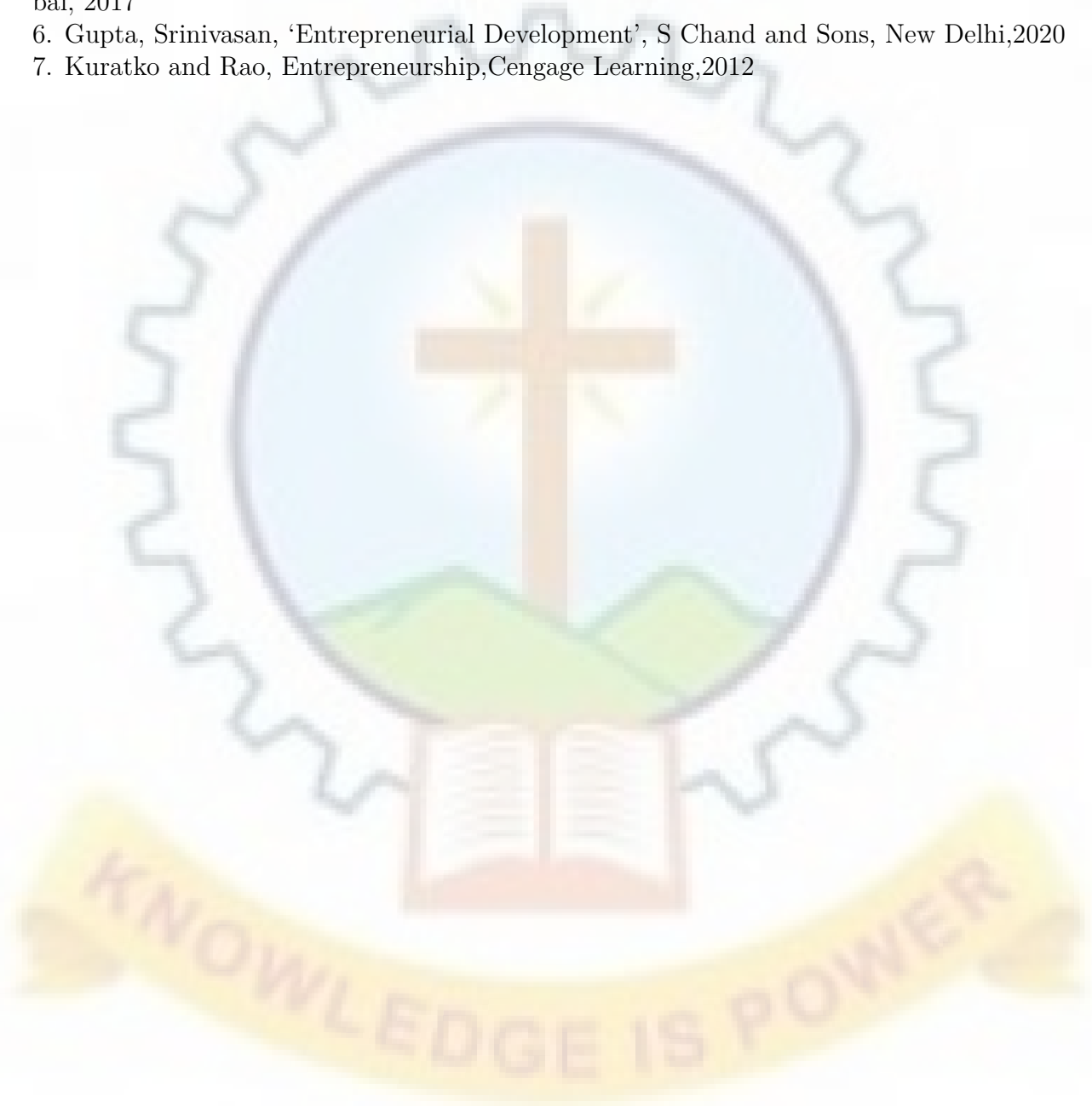
**Projects:** Identification and selection of projects, project report, contents and formulation, elements of project formulation, project design and network analysis, concept of project evaluation, methods of project evaluation: internal rate of return method and net present value method.

### **MODULE 5**

**Management of Enterprises:** objectives and functions of management, scientific management, general and strategic management; introduction to human resource management: planning, job analysis, training, recruitment and selection, marketing and organizational dimension of enterprises; enterprise financing, raising and managing capital, shares, debentures, bonds, cost of capital; break-even analysis, balance sheet analysis.

**Text Books**

1. Ram Chandran, Entrepreneurial Development, Tata McGraw Hill, New Delhi, 2008
2. Saini, J. S. Entrepreneurial Development Programmes and Practices, Deep and Deep Publications, 2012
3. Khanka, SS. Entrepreneurial Development, S Chand and Company Ltd., New Delhi, 2007
4. Badhai, B Entrepreneurship for Engineers, Dhanpat Rai and co, 2006
5. Desai, Vasant, Project Management and Entrepreneurship', Himalayan Publishing, Mumbai, 2017
6. Gupta, Srinivasan, 'Entrepreneurial Development', S Chand and Sons, New Delhi, 2020
7. Kuratko and Rao, Entrepreneurship, Cengage Learning, 2012





**COURSE CONTENTS AND LECTURE SCHEDULE**

| <b>No</b> | <b>Topic</b>                                                                                         | <b>No of Lecture/Tutorial Hours</b> |
|-----------|------------------------------------------------------------------------------------------------------|-------------------------------------|
|           | <b>Module 1</b>                                                                                      | <b>7</b>                            |
| 1.1       | Entrepreneurship: definition, requirements to be an entrepreneur, entrepreneur and intrapreneur.     | 1                                   |
| 1.2       | Entrepreneur and manager, growth of entrepreneurship in India, women entrepreneurship.               | 1                                   |
| 1.3       | Rural and urban entrepreneurship.                                                                    | 1                                   |
| 1.4       | Entrepreneurial motivation: motivating factors, motivation theories, Maslow's Need Hierarchy Theory. | 2                                   |
| 1.5       | McClelland's acquired need theory, government's policy actions towards entrepreneurial motivation.   | 1                                   |
| 1.6       | Entrepreneurship development programmes.                                                             | 1                                   |
|           | <b>Module 2</b>                                                                                      | <b>7</b>                            |
| 2.1       | Small scale, medium scale and large scale enterprises.                                               | 2                                   |
| 2.2       | Role of small enterprises in economic development.                                                   | 1                                   |
| 2.3       | Proprietorship, partnership.                                                                         | 1                                   |
| 2.4       | Limited companies.                                                                                   | 1                                   |
| 2.5       | Co-operatives: their formation, capital structure and source of finance.                             | 2                                   |
|           | <b>Module 3</b>                                                                                      | <b>6</b>                            |
| 3.1       | Institutional support towards the development of entrepreneurship in India.                          | 1                                   |
| 3.2       | Technical consultancy organizations.                                                                 | 1                                   |
| 3.3       | Government programs, policies, incentive and institutional networking.                               | 2                                   |
| 3.4       | Women entrepreneurship development in India.                                                         | 1                                   |
| 3.5       | Promotional schemes.                                                                                 | 1                                   |
|           | <b>Module 4</b>                                                                                      | <b>7</b>                            |
| 4.1       | Identification and selection of projects.                                                            | 1                                   |
| 4.2       | Project report, contents and formulation.                                                            | 1                                   |
| 4.3       | Elements of project formulation.                                                                     | 1                                   |
| 4.4       | Project design and network analysis.                                                                 | 1                                   |
| 4.5       | Concept of project evaluation, methods of project evaluation.                                        | 1                                   |
| 4.6       | Internal rate of return method.                                                                      | 1                                   |
| 4.7       | Net present value method.                                                                            | 1                                   |
|           | <b>Module 5</b>                                                                                      | <b>8</b>                            |
| 5.1       | Objectives and functions of management, scientific management, general and strategic management.     | 1                                   |
| 5.2       | Introduction to human resource management, planning, job analysis.                                   | 1                                   |

|     |                                                                                                 |                 |
|-----|-------------------------------------------------------------------------------------------------|-----------------|
| 5.3 | Training, recruitment and selection.                                                            | 1               |
| 5.4 | Marketing and organizational dimension of enterprises.                                          | 1               |
| 5.5 | Enterprise financing, raising and managing capital, shares, debentures, bonds, cost of capital. | 2               |
| 5.6 | Break-even analysis.                                                                            | 1               |
| 5.7 | Balance sheet analysis.                                                                         | 1               |
|     | <b>Total Hours</b>                                                                              | <b>35 Hours</b> |

### CO ASSESSMENT QUESTIONS

#### Course Outcome 1 (CO 1):

1. Explain the Concept of entrepreneur. .
2. Explain the characteristics and qualities of entrepreneurs.

#### Course Outcome 2 (CO 2):

1. Describe a few ways to promote innovations in an organization..
2. Discuss the motivational theories.

#### Course Outcome 3 (CO 3):

1. Explain the various types of ownerships available to entrepreneurs.
2. Describe features of limited companies.

#### Course Outcome 4 (CO 4):

1. Explain the factors influencing project plan.
2. Write a note on IRR.

#### Course Outcome 5 (CO 5):

1. List the sources of finance.
2. Define break-even analysis.

**MODEL QUESTION PAPER**

**QP CODE:**

**Pages: 5**

**Reg.No.:** .....

**Name:** .....

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),  
KOTHAMANGALAM**

**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2028**

**Course Code: B24EC4G35**

**Course Name: ENTREPRENEURSHIP**

**Max. Marks: 100**

**Duration: 3 hours**

**PART A**

**Answer all questions. Each question carries 3 marks**

1. "Entrepreneurs are made or born." Give your views.
2. Explain the role of entrepreneurial development programme (EDP).
3. Explain the organizational structure of SMEs.
4. Explain the various types of ownerships available to entrepreneurs
5. Write a note on Women entrepreneurs.
6. Discuss the incentives available for enterprise setting.
7. List the Explain the factors influencing project plan.
8. Discuss the aspects and methods of project appraisal.
9. List the job analysis methods.
10. Explain raising and managing capital.

**PART B**

**Answer any one question from each module. Each question carries 14 marks**

**Module I**

11. Explain the characteristics and qualities of entrepreneurs. (14)
12. Discuss the Maslow's need hierarchy theory. (14)

**Module II**

13. Explain the role and importance of Small and Medium Enterprises. (14)
14. Explain the various types of ownerships available to entrepreneurs. Discuss each form in brief. (14)

**Module III**

15. Explain the role of central Government and state Government in promoting entrepreneurship. (14)
16. What is the status of women entrepreneurs in contemporary business? Illustrate with examples. (14)

**Module IV**

17. Explain IRR. (14)
18. Explain net present value method. (14)

**Module V**

19. What is working capital? Why is it important for any enterprise? Explain. (14)
20. Discuss break- even analysis. (14)

| B24EC4L14 | PROJECT<br>PHASE II | L | T | P  | S | CREDIT | YEAR OF<br>INTRODUCTION |
|-----------|---------------------|---|---|----|---|--------|-------------------------|
|           |                     | 0 | 0 | 12 | 3 |        |                         |

**Preamble:**

The course 'Project Work Phase II' evokes innovation and invention skills in students. It offers an opportunity to synthesize and apply learned knowledge and analytical skills toward developing a functional prototype, simulation, or technology solution. Projects should align with thrust areas of the engineering stream or be interdisciplinary, prioritizing societal problems, sustainable development (aligned with UN SDGs such as SDG 7: Affordable & Clean Energy, SDG 9: Industry/Innovation/Infrastructure, SDG 13: Climate Action), and indigenous technologies.

**Course Objectives**

- To apply engineering knowledge in practical problem-solving and implementation.
- To foster innovation in design, development, and testing of sustainable engineering solutions.
- To develop teamwork, project management, and effective communication skills.

**Course Outcomes:**

After the completion of the course the student will be able to

|             |                                                                                                                   |
|-------------|-------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Model, analyze, and solve real-world engineering problems by applying cross-domain knowledge. (Apply)             |
| <b>CO 2</b> | Develop, test, and validate sustainable products/processes/technologies aligned with relevant UN SDGs.. (Apply)   |
| <b>CO 3</b> | Function effectively in teams, manage tasks/resources, and adhere to ethical/professional norms. (Apply)          |
| <b>CO 4</b> | Identify research/technology gaps and propose innovative solutions with implementation evidence. (Analyze)        |
| <b>CO 5</b> | Organize and communicate technical findings effectively through reports, presentations, and publications. (Apply) |

**Mapping of Course Outcomes With Program Outcomes** (Latest Tier-1 NBA POs - 11 POs)

|      | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| CO 1 | 3   | 3   | 2   | 2   | 2   | 2   | 1   | 1   | 1   | 1    | 2    |
| CO 2 | 2   | 2   | 3   | 1   | 1   | 3   | 2   | 1   | 1   | 1    | 2    |
| CO 3 |     |     |     |     | 2   | 1   | 2   | 3   | 2   | 3    | 2    |
| CO 4 | 2   | 3   | 3   | 2   | 2   | 2   | 1   | 1   |     | 2    | 2    |
| CO 5 |     |     |     |     | 2   | 1   | 1   | 1   | 3   | 2    | 2    |

**Abstract POs defined by National Board of Accreditation (new Tier-1, GAPC v4.0 aligned with Washington Accord)**

| PO   | Broad PO                                                                                |
|------|-----------------------------------------------------------------------------------------|
| PO1  | Engineering Knowledge                                                                   |
| PO2  | Problem Analysis                                                                        |
| PO3  | Design/Development of Solutions                                                         |
| PO4  | Conduct Investigations of Complex Problems                                              |
| PO5  | Engineering Tool Usage                                                                  |
| PO6  | The Engineer and The World (society, sustainability/SDGs, legal/ethical considerations) |
| PO7  | Ethics (including inclusivity, diversity, and professional responsibility)              |
| PO8  | Individual and Collaborative Team Work                                                  |
| PO9  | Communication                                                                           |
| PO10 | Project Management and Finance                                                          |
| PO11 | Life-Long Learning                                                                      |

**PROJECT PHASE II Targets**

- In-depth study and refinement of the topic based on Phase-I report.
- Review and finalization of problem approach/methodology.
- Detailed action plan with timelines, resource allocation, and teamwork.
- Comprehensive analysis, modeling, simulation, design, experimentation, prototype development, testing, and validation.
- Final product/process development, results analysis, conclusions, future directions (with SDG alignment where applicable).
- Preparation of conference/journal paper (if feasible).
- Presentation in university/state/national/international project expos.



- IPR filing (patent/publication) if applicable.
- Standard-format report preparation for departmental assessment.
- Final presentation and viva-voce with external expert.

**Evaluation Guidelines & Rubrics Total: 150 marks** (Minimum to pass: 75)

|                                                                 |            |
|-----------------------------------------------------------------|------------|
| Project progress evaluation by guide                            | :30 marks  |
| Two interim evaluations by Evaluation Committee                 | :50 marks  |
| Final Evaluation by Evaluation Committee                        | :40 marks  |
| Quality of the report evaluated by committee                    | :25 marks  |
| Paper publication / acceptance in conference or indexed journal | :5 marks   |
| Total                                                           | :150 marks |

**Paper publication / acceptance (5 marks):** Awarded only if at least one paper (authored by the student team) is published or accepted in:

- A recognized national/international conference, or
- An indexed journal.
- Proof required: acceptance letter / publication link / DOI / conference proceedings page

**Evaluation committee:** HoD/senior faculty, Project coordinator, supervisor. Final committee: Project coordinator, industry/research/academic external expert, senior faculty from sister department.

**Evaluation by the Guide (30 Marks)**

- **Project Scheduling & Work Distribution (5):** Detailed timelines, WBS, balanced allocation.
- **Literature Survey (4):** Outstanding depth/breadth (updated from Phase-I).
- **Student's Diary/Daily Log (7):** Regular signed records of progress, observations, sketches, reflections; promotes documentation and reasoning.
- **Individual Contribution (9):** Evidence of meaningful, equitable input per student.
- **Project Completion/Demonstration (5):** Functional prototype/demo to guide; objectives met, results verified.

### Rubrics for evaluation by the Guide

| Aspect / Parameter                                                              | Marks | Poor (0-1 for 5-mark items; 0-2 for 7-9 mark items)                                                                                    | Fair (2 for 5-mark; 3-4 for 7-9 mark)                                                                                   | Very Good (3-4 for 5-mark; 5-7 for 7-9 mark)                                                                                                  | Outstanding (5 for 5-mark; 8-9 for 7-9 mark; full for others)                                                                                                                    |
|---------------------------------------------------------------------------------|-------|----------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Project Scheduling & Distribution of Work among Team members [CO3,CO4/PO8,PO10] | 5     | No meaningful scheduling or WBS; tasks unclear, unbalanced, or not assigned; no evidence of planning from Phase I.                     | Basic scheduling exists but incomplete/in-effective; distribution skewed or vague; partial follow-up from Phase I plan. | Good detailed scheduling with timelines and WBS; distribution mostly balanced and supported by discussions/journal; plan followed reasonably. | Excellent comprehensive scheduling, clear timelines, well-defined equitable WBS; strong documentation (e.g., tools/journal); all members actively engaged per capabilities.      |
| Literature Survey [CO1, CO5 / PO1, PO2]                                         | 4     | Minimal or superficial survey; lacks depth, relevance, or updates from Phase I; no critical analysis/gap identification.               | Basic survey with some sources; limited depth or organization; partial updates but inadequate analysis.                 | Comprehensive survey with good range of sources; clear organization, relevant updates from Phase I;                                           | Outstanding in-depth, critical survey; broad-range/relevant sources; excellent synthesis, gap identification, and alignment with societal/SDG needs; fully refined from Phase I. |
| Student's Diary / Daily Log [CO4, CO5 / PO9, PO11]                              | 7     | Incomplete/irregular entries; little/no detail, sketches, reflections, or signatures; no evidence of documentation habit or reasoning. | Entries sporadic; basic observations but limited depth/reflection; inconsistent signatures or detail.                   | Regular entries with good detail on progress, observations, sketches, suggestions; mostly signed; shows developing thought process.           | Exemplary daily/weekly records: detailed, reflective, with sketches/-drawings; consistent signatures; fosters strong reasoning, documentation, and lifelong learning habits.     |

|                                                     |   |                                                                                                             |                                                                                                              |                                                                                                                       |                                                                                                                                                               |
|-----------------------------------------------------|---|-------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Individual Contribution [CO3 / PO8]                 | 9 | Minimal/no meaningful participation by some/all members; contributions superficial or absent across stages. | Some contribution but uneven/limited; certain members dominate or under-contribute; superficial involvement. | Good individual input evident in most stages; contributions mostly equitable and documented (e.g., via journal/demo). | Outstanding equitable, substantial contributions by each member; clear leadership/impact in key stages; well-evidenced via logs, demos, and team interaction. |
| Completion of the Project [CO1, CO2, CO5 / PO1-PO6] | 5 | No functional demonstration; objectives not met; results unverifiable or absent.                            | Partial demonstration; some objectives met but significant gaps; results limited/incomplete.                 | Good demonstration; most objectives achieved; results verifiable with minor issues.                                   | Full functional demonstration (prototype/simulation); all objectives met; results validated, with clear evidence of innovation/sustainability/SDG relevance.  |

#### Rubrics for Interim Evaluation – 1 (25 Marks)

| Sl. No. | Parameters                                           | Marks | Poor (0-1)                                                                                                               | Fair (2-3)                                                                          | VeryGood (4)                                                                                                                | Outstanding (5)                                                                                                          |
|---------|------------------------------------------------------|-------|--------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| 2-a     | Novelty of idea & Implementation scope [CO5] (Group) | 5     | No useful societal/SDG-relevant requirement addressed; lacks originality; routine implementation without fresh features. | Some aspects implementable; limited originality; minimal improvements over Phase-I. | Good implementable scope with evidence of originality; fresh specifications/features; independent learning/ingenuity shown. | Highly novel/original idea (unreported); ingenious, SDG-aligned implementation; fully implementable/publishable quality. |

|     |                                                             |   |                                                                                         |                                                                          |                                                                                              |                                                                                                                                    |
|-----|-------------------------------------------------------------|---|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| 2-b | Effective-ness of task distribution [CO3/PO8] (Group)       | 5 | No distribu-tion; mem-bers unclear on roles.                                            | Allocated but ineffec-tive/skewed; some mem-bers under-utilized.         | Good allo-cation via discussion-s/journal; mostly equitable/-followed.                       | Excellent equitable distri-bution per ca-pabilities; well-documented (journal/brain-storming); all actively con-tribute.           |
| 2-c | Adherence to project schedule [CO4/PO10] (Group)            | 5 | Minimal planning; no adherence to Phase-I plan; unclear re-sources/bud-get; no journal. | Some progress over Phase-I; vague re-sources/bud-get; partial schedules. | Good planning/follow-up; resources listed; plan mostly fol-lowed; jour-nal updated somewhat. | Detailed plan-ning/tools (e.g., revision con-trol); resource procurement on track; journal comprehensive; strong team interaction. |
| 2-d | Interim Results & Progress [CO1/CO5] (Group)                | 5 | No mean-ingful pro-gress/results from Phase-I continuation.                             | Few re-sults; limited analy-sis/infer-ences.                             | Several results achieved; issues iden-tified with partial solu-tions.                        | Significant progress; clear inferences; SDG/societal impact evident.                                                               |
| 2-e | Presentation & Docu-mentation [CO5/PO9] (Group/Indi-vidual) | 5 | Poor clar-ity/organ-ization; no understand-ing shown.                                   | Needs major im-provement in struc-ture/deliv-ery.                        | Adequate content/de-livery.                                                                  | Professional, confident, well-structured presentation.                                                                             |

### Rubrics for Interim Evaluation – 2 (25 Marks)

| Sl. No. | Parameters                                                       | Marks | Poor (0-3)                                               | Fair (4-6)                                       | VeryGood (7-9)                              | Outstanding (10)                                            |
|---------|------------------------------------------------------------------|-------|----------------------------------------------------------|--------------------------------------------------|---------------------------------------------|-------------------------------------------------------------|
| 2-f     | Application of Engineering knowledge [CO1/PO1-PO5] (Individ-ual) | 10    | No evidence of knowledge application in implemen-tation. | Basic ap-plication; inadequate for method-ology. | Reasonable applica-tion in design/test-ing. | Excellent, adaptive use of knowledge for robust solu-tions. |

|     |                                                              |   |                                         |                                       |                                                |                                                                   |
|-----|--------------------------------------------------------------|---|-----------------------------------------|---------------------------------------|------------------------------------------------|-------------------------------------------------------------------|
| 2-g | Involvement of individual members [CO3/PO8] (Individual)     | 5 | Minimal/no participation.               | Superficial/limited contribution.     | Good involvement in core activities.           | Leadership/-substantial technical impact.                         |
| 2-h | Results and inferences [CO5/PO2-PO4] (Group)                 | 5 | No outcomes achieved; no analysis.      | Few outcomes; superficial inferences. | Many outcomes; good analysis/issues addressed. | Comprehensive outcomes; deep inferences; SDG-aligned suggestions. |
| 2-i | Documentation and presentation [CO5/PO9] (Individual/-Group) | 5 | Poor individual understanding/delivery. | Needs improvement overall.            | Satisfactory performance.                      | Professional, clear, confident delivery.                          |

### Rubrics for Final Evaluation (40 Marks)

| Sl. No. | Parameters                                                        | Marks | Poor (0-3)                                          | Fair (4-6)                                    | Very Good (7-9)                                                    | Outstanding (10)                                                                  |
|---------|-------------------------------------------------------------------|-------|-----------------------------------------------------|-----------------------------------------------|--------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| 2-j     | Engineering knowledge application [CO1/PO1-PO5] (Group)           | 10    | No effective application in final design/execution. | Partial application; gaps in methodology.     | Good application; minor improvements needed.                       | Outstanding integration for effective, validated solutions.                       |
| 2-k     | Relevance to societal /industrial/SDG needs [CO2/PO3/PO6] (Group) | 5     | No clear relevance.                                 | Some relevance; limited translation to specs. | Strong relevance; problem solved with societal/SDG considerations. | Exceptional impact; outstanding contribution to sustainable /societal challenges. |



|     |                                                                    |    |                                      |                                 |                                                  |                                                                             |
|-----|--------------------------------------------------------------------|----|--------------------------------------|---------------------------------|--------------------------------------------------|-----------------------------------------------------------------------------|
| 2-l | Innovation/Novelty/Creativity [CO5/PO3] (Group)                    | 5  | Routine; no originality.             | Limited freshness.              | Good ingenuity; implementable with improvements. | Highly novel/ingenious; publishable/IPR potential.                          |
| 2-m | Quality of results/conclusions/solutions [CO1/CO5/PO2/PO4] (Group) | 10 | None achieved; no valid conclusions. | Few achieved; limited analysis. | Many achieved; good inferences/suggestions.      | Most achieved; extensive validation; clear future directions/SDG alignment. |
| 2-n | Presentation/Communication [CO5/PO9] (Group/Individual)            | 10 | Poor organization/delivery.          | Needs improvement.              | Good flow/professionalism.                       | Exceptional clarity/-confidence; engaging technical communication.          |

#### Rubrics for Report Evaluation (25 Marks)

| Sl. No. | Parameters       | Marks | Poor (0-9)                                                                                   | Fair (10-15)                                                                         | Very Good (16-22)                                                                                     | Outstanding (23-25)                                                                                                                                                 |
|---------|------------------|-------|----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2-o     | Report [CO5/PO9] | 25    | Shallow/non-standard; poor organization; inadequate references; inconsistent/unprofessional. | Partial standard format; language/references need improvement; some inconsistencies. | Systematic/standard format; good organization; consistent formatting; most references cited properly. | Exceptionally organized/professional; all references/diagrams/tables correctly cited/-captioned; clear, readable, high-quality language; publication-ready quality. |



| B24ECML8X | MINOR PROJECT | L | T | P | S  | CREDIT | YEAR OF INTRODUCTION |
|-----------|---------------|---|---|---|----|--------|----------------------|
|           |               | 0 | 0 | 3 | 12 | 6      | 2024                 |

### **Preamble:**

The Minor Project aims to

- Assess students' ability to transform theoretical knowledge into a functional working model.
- Enable experience in organizing and implementing small-scale projects.
- Facilitate design and development of a moderately complex project (hardware or hardware-software combination) with practical, sustainable applications.

### **Course Plan**

In groups of up to 4 students, design and develop a moderately complex system that addresses a real-world need or application (a functional working prototype/model is required). The project must meaningfully incorporate fundamental product design principles, including innovation, reliability, and aesthetics/ergonomics.

Students (in consultation with faculty/advisor):

- Identify topic of interest.
- Conduct literature review and gather information.
- State objectives and develop methodology.
- Perform design/fabrication/coding/programming.
- Demonstrate novelty/results/outputs (with SDG alignment where applicable).

Progress evaluated via minimum two reviews by committee (constituted by HoD). Submit project report at semester end. Demonstrate product against full specifications. Weightage given to innovative concepts, reliability, aesthetics/ergonomics, and societal/SDG relevance.

## Course Outcomes

After the completion of the course the student will be able to

|             |                                                                                                              |
|-------------|--------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Apply acquired knowledge in the selected technology area for project development and implementation. [Apply] |
| <b>CO 2</b> | Identify, discuss, and justify technical/design aspects of the project systematically. [Analyze]             |
| <b>CO 3</b> | Reproduce, improve, and refine technical aspects for engineering projects. [Apply]                           |
| <b>CO 4</b> | Collaborate effectively as a team in technical project development. [Apply]                                  |
| <b>CO 5</b> | Communicate and report project activities/findings effectively (written/oral). [Apply]                       |

## Mapping of Course Outcomes With Program Outcomes

|             | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> |
|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|
| <b>CO 1</b> | 3          | 3          | 3          | 2          | 2          | 3          | 1          | 1          | 1          | 1           | 2           |
| <b>CO 2</b> | 3          | 3          | 3          | 2          | 1          | 3          | 1          | 1          | 1          | 2           | 2           |
| <b>CO 3</b> | 3          | 3          | 3          | 2          | 2          | 3          | 1          | 1          | 1          | 1           | 2           |
| <b>CO 4</b> |            |            |            |            |            | 1          | 2          | 3          | 2          | 3           | 2           |
| <b>CO 5</b> |            |            |            |            | 1          | 1          | 1          | 2          | 3          | 2           | 2           |

**Evaluation Guidelines:** Total: 150 marks (CIE 75 + ESE 75). Minimum pass as per university norms.

### Split-up of CIE (75 marks)

|                                                                                                                   |           |
|-------------------------------------------------------------------------------------------------------------------|-----------|
| Attendance                                                                                                        | :10 marks |
| Marks awarded based on guide's evaluation                                                                         | :15 marks |
| Project Report                                                                                                    | :10 marks |
| Evaluation by Committee                                                                                           | :40 marks |
| (Committee: 3 members – HoD/senior faculty, Academic coordinator/program coordinator, project guide/coordinator.) |           |

### Split-up of ESE (75 Marks) (1-hour duration)

|                                               |           |
|-----------------------------------------------|-----------|
| Level of Completion                           | :10 marks |
| Demonstration of functionality/specifications | :25 marks |
| Project Report                                | :10 marks |
| Viva-voice                                    | :20 marks |
| Presentation                                  | :10 marks |

**Enhanced Rubrics for All Evaluation Components**

**1. Guide's Evaluation (CIE – 15 Marks)** Holistic assessment by guide (regular monitoring, involvement, progress).

| Parameter                                                        | Marks Allocation (out of 15) | Poor (0–3)                                           | Fair (4–7)                                   | Good (8–11)                                   | Very Good (12–14)                                           | Outstanding (15)                                                                  |
|------------------------------------------------------------------|------------------------------|------------------------------------------------------|----------------------------------------------|-----------------------------------------------|-------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Project Planning, Scheduling & Task Distribution [CO4/PO8, PO10] | 4                            | No plan/WBS; unbalanced/un-clear roles.              | Basic plan; skewed distribution.             | Reasonable plan/-timelines; mostly balanced.  | Detailed WBS/-timelines; equitable distribution documented. | Comprehensive planning; excellent equitable allocation; strong team coordination. |
| Technical Progress & Implementation [CO1, CO3 / PO1-PO5]         | 5                            | Minimal progress; major gaps in design/-fabrication. | Partial implementation; basic functionality. | Good progress; most objectives met partially. | Strong implementation; refined technical aspects.           | Excellent execution; innovative/refined design with SDG relevance.                |
| Individual & Team Involvement [CO4 / PO8]                        | 3                            | Low/no participation by some members.                | Uneven contribution.                         | Good involvement; fair equity.                | Consistent active participation.                            | Outstanding collaboration; leadership evident.                                    |
| Documentation & Regular Reviews [CO5 / PO9, PO11]                | 3                            | Poor/irregular records; no updates.                  | Basic records; inconsistent.                 | Good records; regular updates.                | Detailed logs/reviews.                                      | Exemplary documentation; reflective & timely.                                     |

## 2. Evaluation by Committee (CIE – 40 Marks)

Based on interim reviews (progress, demo, knowledge, involvement).

| Parameter                                              | Marks (out of 40) | Poor (0–10)                         | Fair (11–20)                      | Good (21–28)                             | Very Good (29–35)                                | Outstanding (36–40)                                         |
|--------------------------------------------------------|-------------------|-------------------------------------|-----------------------------------|------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|
| Technical Depth & Justification [CO1-CO3 / PO1-PO4]    | 15                | Superficial; no justification/gaps. | Basic explanation; limited depth. | Reasonable justification; some analysis. | Strong technical discussion/systematic approach. | Excellent depth; critical analysis; innovative/SDG-aligned. |
| Innovation & Practical Relevance [CO1, CO3 / PO3, PO6] | 10                | No novelty; routine.                | Limited innovation.               | Some novelty/practical aspects.          | Good innovation; practical/SDG relevance.        | Highly innovative; strong societal/SDG impact.              |
| Team Work & Involvement [CO4 / PO8]                    | 8                 | Poor collaboration.                 | Uneven involvement.               | Good team effort.                        | Strong collaboration.                            | Exemplary teamwork/leadership.                              |
| Communication & Presentation Readiness [CO5 / PO9]     | 7                 | Poor clarity.                       | Needs improvement.                | Adequate.                                | Clear & structured.                              | Professional & confident.                                   |

## 3. ESE Components – Enhanced Rubrics (75 Marks Total)

### • Level of Completion (10 Marks) [CO1–CO3]

- **Poor (0–2):** Incomplete; major unfinished parts.
- **Fair (3–5):** Partially complete; significant gaps.
- **Good (6–7):** Mostly complete; minor issues.
- **Very Good (8):** Fully complete with good quality.
- **Outstanding (9–10):** Exceptionally complete; exceeds expectations (innovative/SDG features).

### • Demonstration of Functionality/Specifications (25 Marks) [CO1, CO3 / PO3]

- **Poor (0–6):** Non-functional; fails specifications.
- **Fair (7–12):** Basic functionality; many failures.
- **Good (13–18):** Functional; meets most specifications with issues.
- **Very Good (19–22):** Reliable demonstration; meets all key specifications.
- **Outstanding (23–25):** Flawless; innovative features; reliable/SDG-aligned performance.
- **Project Report (10 Marks – CIE + ESE combined) [CO5 / PO9]**
  - **Poor (0–2):** Poor organization; incomplete or missing sections.
  - **Fair (3–5):** Basic format; weak language/references.
  - **Good (6–7):** Systematic; mostly consistent.
  - **Very Good (8):** Well-organized; good references.
  - **Outstanding (9–10):** Professional quality; excellent structure/readability; proper citations and SDG discussion.
- **Viva-voce (20 Marks) [CO2, CO5 / PO2, PO9]**
  - **Poor (0–5):** Unable to explain basics; lacks understanding.
  - **Fair (6–10):** Limited answers; frequent prompting.
  - **Good (11–14):** Answers most questions reasonably.
  - **Very Good (15–17):** Confident; good depth and explanation.
  - **Outstanding (18–20):** Excellent articulation; integrates concepts; handles challenges fluently.
- **Presentation (10 Marks) [CO5 / PO9]**
  - **Poor (0–2):** Poor delivery and structure.
  - **Fair (3–5):** Needs major improvement.
  - **Good (6–7):** Clear and logical.
  - **Very Good (8):** Professional flow.
  - **Outstanding (9–10):** Engaging and confident; excellent visuals and technical clarity.



| <b>B24ECHL8X</b> | <b>HONOURS PROJECT</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>S</b> | <b>CREDIT</b> | <b>YEAR OF INTRODUCTION</b> |
|------------------|------------------------|----------|----------|----------|----------|---------------|-----------------------------|
|                  |                        | 0        | 0        | 6        | 9        |               |                             |

### Preamble

The Honours Project aims to assess and develop advanced capabilities in B.Tech Honours students by transforming deep theoretical knowledge into an innovative, functional system, model, prototype, process, software solution, or technology intervention with research depth and practical/societal impact. It enables hands-on experience in organizing, implementing, and leading moderately complex to advanced projects (hardware, software, simulation-based, experimental, process-oriented, or hybrid) relevant to the student's core engineering branch or interdisciplinary areas. Emphasis is placed on product/process design concepts, novelty, reliability, aesthetics/ergonomics/user-centric design (where applicable), sustainability (aligned with UN SDGs such as SDG 9: Industry, Innovation and Infrastructure, SDG 13: Climate Action, SDG 7: Affordable and Clean Energy, SDG 6: Clean Water and Sanitation, SDG 11: Sustainable Cities and Communities, or other relevant goals), and potential for publication, patent/IPR, or technology transfer. Students (individual or in groups of 2–4) consult faculty/guides to identify advanced, relevant topics, conduct a thorough literature review and gap analysis, define clear objectives and methodology, implement/develop/validate the solution through modeling, simulation, experimentation, prototyping, or deployment, analyze results rigorously, and demonstrate outcomes with evidence of innovation and real-world applicability.

### Course Plan

- Identify advanced core engineering branch topic in consultation with faculty/advisor.
- Conduct in-depth literature review and gap analysis.
- State objectives, develop systematic methodology (with SDG alignment where relevant).
- Design/fabricate/develop hardware/software/codes, implement, test, refine.
- Demonstrate novelty, functionality, reliability, aesthetics/ergonomics through results/outputs.
- Progress evaluated via minimum two reviews by committee.
- Submit comprehensive project report; demonstrate full design specifications.
- Explore conference/journal publication or IPR filing.



## Course Outcomes

After the completion of the course the student will be able to

|             |                                                                                                                                                |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | CO1 Apply and extend acquired knowledge in selected core engineering branch /technology area for advanced Honours project development. [Apply] |
| <b>CO 2</b> | Identify, discuss, justify, and systematically approach technical/design aspects of innovative projects with SDG/societal relevance. [Analyze] |
| <b>CO 3</b> | Reproduce, improve, refine, and validate technical solutions for complex engineering projects. [Apply/Analyze]                                 |
| <b>CO 4</b> | Collaborate effectively as a team in development and management of advanced technical projects. [Apply]                                        |
| <b>CO 5</b> | Communicate and report project activities, findings, and innovations effectively (written/oral). [Apply]                                       |

## Mapping of Course Outcomes With Program Outcomes

|             | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> |
|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|
| <b>CO 1</b> | 3          | 3          | 3          | 2          | 2          | 3          | 1          | 1          | 1          | 1           | 2           |
| <b>CO 2</b> | 3          | 3          | 3          | 3          | 2          | 3          | 2          | 1          | 1          | 2           | 2           |
| <b>CO 3</b> | 3          | 3          | 3          | 2          | 2          | 3          | 1          |            | 1          | 1           | 2           |
| <b>CO 4</b> |            |            |            |            | 1          | 1          | 2          | 3          | 2          | 3           | 2           |
| <b>CO 5</b> |            |            |            |            | 1          |            | 1          | 1          | 3          | 2           | 2           |

**Evaluation Scheme:** (Maintained as per attached document) **Total: 150 marks** (CIE 75 + ESE 75; ESE duration 1 hour). Evaluation by 3-member committee (HoD/senior faculty, academic/program coordinator, project guide/coordinator). Committee assesses completion, functionality/specs demonstration, presentation, viva, knowledge, involvement.

### Split-up of CIE (75 marks)

|                                           |           |
|-------------------------------------------|-----------|
| Attendance                                | :10 marks |
| Marks awarded based on guide's evaluation | :15 marks |
| Project Report                            | :10 marks |
| Evaluation by Committee                   | :40 marks |

### Split-up of ESE (75 Marks)

|                                |           |
|--------------------------------|-----------|
| Level of Completion            | :10 marks |
| Demonstration of functionality | :25 marks |
| Project Report                 | :10 marks |
| Viva-voice                     | :20 marks |
| Presentation                   | :10 marks |

**Enhanced Rubrics** (Progressive levels tied to COs/POs/SDGs; evidence-based for fairness)

**1. Guide's Evaluation (CIE – 15 Marks)** Holistic assessment via regular monitoring, logs, contribution, progress.

| Aspect                                                          | Marks Allocation | Poor (0–3)                           | Fair (4–7)                       | Good (8–11)                             | Very Good (12–14)                        | Outstanding (15)                                      |
|-----------------------------------------------------------------|------------------|--------------------------------------|----------------------------------|-----------------------------------------|------------------------------------------|-------------------------------------------------------|
| Progress Scheduling/Task Distribution [CO4/PO8, PO10]           | ~4               | No plan/adherence; unbalanced roles. | Basic plan; skewed/in-effective. | Reasonable scheduling; mostly balanced. | Detailed WBS/-time-lines; equitable.     | Exemplary tools/planning;full SDG aligned engagement. |
| Innovation / Literature/ SDG Relevance [CO2, CO3/PO2, PO3, PO6] | ~5               | Superficial; no novelty/SDG link.    | Limited depth/-gaps.             | Good review; some innovation.           | Strong analysis; SDG-integrated novelty. | Outstanding research; creative/-sustainable impact.   |
| Individual/Team Contribution & Diary/Log [CO4, CO5 / PO8, PO11] | ~6               | Minimal participation/no records.    | Limited/-superficial.            | Good input; regular logs.               | Substantial/reflective.                  | Leadership/impact; exemplary documentation.           |

**2. Evaluation by Committee (CIE – 40 Marks)** Based on interim reviews (progress, demo, knowledge, involvement).

| Parameter                                                        | Marks | Poor (0–8)                        | Fair (9–16)              | Good (17–24)                    | VeryGood (25-32)                  | Outstanding (33-40)                               |
|------------------------------------------------------------------|-------|-----------------------------------|--------------------------|---------------------------------|-----------------------------------|---------------------------------------------------|
| Technical Depth/Justification / SDG Alignment [CO1–CO3/ PO1–PO6] | 15    | Major gaps; no justification/SDG. | Basic; limited analysis. | Reasonable; some justification. | Strong / systematic / SDG-linked. | Exceptional depth; innovative/refined/SDG-impact. |
| Team-work/Involvement [CO4/PO8]                                  | 10    | Uneven/no collaboration           | Limited equity.          | Good teamwork.                  | Effective/-collaborative.         | Outstanding leadership/equity.                    |

| <b>Parameter</b>                                  | <b>Marks</b> | <b>Poor (0–8)</b> | <b>Fair (9–16)</b>  | <b>Good (17–24)</b>   | <b>Very Good (25–32)</b> | <b>Out-standing (33–40)</b>                 |
|---------------------------------------------------|--------------|-------------------|---------------------|-----------------------|--------------------------|---------------------------------------------|
| Interim Progress / Functionality [CO3 / PO3, PO5] | 15           | No demo/progress. | Partial/unreliable. | Good interim results. | Advanced/reliable.       | Highly innovative/validation/SDG relevance. |

### **3. ESE – Level of Completion (10 Marks)**

Poor (0–2): Incomplete/no model.

Fair (3–4): Basic; major gaps.

Good (5–6): Most features done.

Very Good (7–8): Near-full; minor issues.

Outstanding (9–10): Fully advanced; exceeds specs/SDG innovation.

### **4. ESE – Demonstration of Functionality (25 Marks)**

Poor (0–5): Non-functional.

Fair (6–10): Partial/unreliable.

Good (11–15): Functional basics.

Very Good (16–20): Reliable/meets most specs.

Outstanding (21–25): Fully functional; innovative/reliable/SDG-aligned.

### **5. ESE – Project Report (10 Marks) (CIE+ESE combined)**

Poor (0–2): Poor/no references.

Fair (3–4): Basic/inconsistent.

Good (5–6): Systematic/good refs.

Very Good (7–8): Professional/SDG discussion.

Outstanding (9–10): Exemplary/publishable.

### **6. ESE – Viva-voce (20 Marks)**

Poor (0–4): No understanding.

Fair (5–8): Basic/prompting needed.

Good (9–12): Good grasp/explanation.

Very Good (13–16): Strong; handles questions.

Outstanding (17–20): Deep insight/integration/SDGs confidently.

### **7. ESE – Presentation (10 Marks)**

Poor (0–2): Unclear/poor delivery.

Fair (3–4): Needs improvement.

Good (5–6): Clear/structured.

Very Good (7–8): Professional/confident.

Outstanding (9–10): Engaging/excellent visuals/communication.