

MAR ATHANASIOUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution
Kothamangalam, Kerala, India



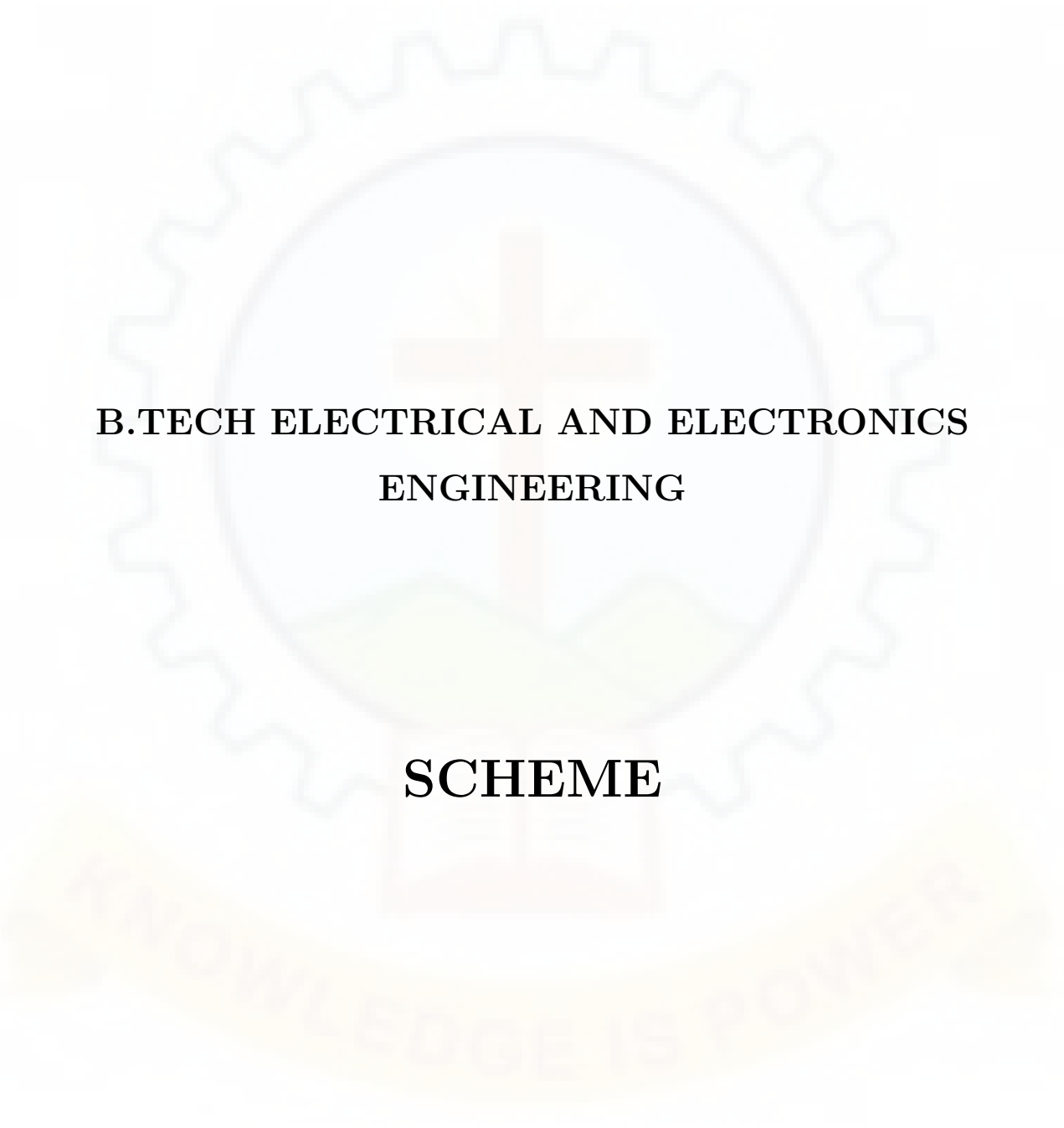
B.TECH ELECTRICAL AND ELECTRONICS ENGINEERING

SCHEME AND SYLLABUS

MAR ATHANASIOUS COLLEGE OF ENGINEERING

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Kothamangalam, Kerala, India



**B.TECH ELECTRICAL AND ELECTRONICS
ENGINEERING**

SCHEME

SEMESTER 1

SLOT	COURSE NO.	COURSES	L-T-P-S	HOURS	CREDIT
A	B24MA1T01	LINEAR ALGEBRA AND MULTIVARIABLE CALCULUS	3-1-0-5	4	4
B	B24ES1T01A	PROBLEM SOLVING AND PROGRAMMING TECHNIQUES(A)	2-1-0-4	3	3
C	B24EE1T01	INTRODUCTION TO ELECTRICAL ENGINEERING	2-2-0-5	4	4
D	B24EE1T02	ELECTRONIC CIRCUITS I	2-1-0-4	3	3
E	B24ES1T03B	COMPUTER AIDED ENGINEERING GRAPHICS(B)	2-1-1-5	4	4
G	B24ES1L01A	PROGRAMMING LAB(A)	0-0-3-2	3	2
H	B24EE1L01	BASIC ELECTRICAL ENGINEERING LAB	0-0-3-2	3	2
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	22

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	B24PH1T01A	ENGINEERING PHYSICS(A)	2-1-0-4	3	3
C	B24CY1T01A	ENGINEERING CHEMISTRY(A)	2-1-0-4	3	3
D	B24ES1T05A	BASIC CIVIL AND MECHANICAL ENGINEERING(A)	2-2-0-5	4	4
E	B24EE1T03	ELECTRICAL MEASUREMENTS	2-1-0-4	3	3
F	B24ES1L04A	BASIC CIVIL AND MECHANICAL ENGINEERING WORKSHOP(A)	0-0-2-1	2	1
G	B24EE1L02	ELECTRONIC CIRCUITS LAB I	0-0-3-2	3	2
H	B24PC1L01A	PHYSICS(A) AND CHEMISTRY LAB(A)	0-0-2-2	2	1
I	B24MC1T03	PROFESSIONAL COMMUNICATION AND ETHICS	2-0-1-4	3	P/F
J	B24MC1L02	IDEA LAB	0-0-3-3	3	P/F
TOTAL				30	21

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	B24EE2T01	CIRCUITS AND NETWORKS	2-2-0-5	4	4
C	B24EE2T02	ELECTRICAL MACHINES I	2-2-0-5	4	4
D	B24EE2T03	DIGITAL ELECTRONICS	2-1-0-4	3	3
E	B24EE2T04	ELECTRONIC CIRCUITS II	2-1-0-4	3	3
G	B24EE2L03	ELECTRICAL MEASUREMENTS LAB	0-0-3-2	3	2
H	B24EE2L04	DIGITAL ELECTRONICS LAB	0-0-3-2	3	2
I	B24MC2T04	UNIVERSAL HUMAN VALUES 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	B24EEM3X	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	B24EE2T05	SIGNALS AND SYSTEMS	2-2-0-5	4	3
C	B24EE2T06	POWER ELECTRONICS	3-1-0-5	4	4
D	B24EE2T07	ELECTROMAGNETIC THEORY	2-1-0-4	3	3
E	B24HU2T01	BUSINESS ECONOMICS AND FINANCIAL MANAGEMENT	3-0-0-4	3	3
F	B24EE2T08	MICROPROCESSORS AND MICROCONTROLLERS	2-2-0-5	4	4
G	B24EE2L05	ELECTRICAL MACHINES LAB I	0-0-3-2	3	2
H	B24EE2L06	ELECTRONIC CIRCUITS LAB II	0-0-3-2	3	2
M	B24EEM4X	MINOR	3-1-0-5	4	4
N	B24EEH4X	HONOURS	2-2-0-5	4	4
TOTAL*				36	25

*Total does not include the credits of honours and minor courses

SEMESTER 5

SLOT	COURSE NO.	COURSES	L-T-P-S	HOURS	CREDIT
A	B24EE3T01	LINEAR CONTROL SYSTEM	2-2-0-5	4	4
B	B24EE3T02	POWER SYSTEM I	2-2-0-5	4	4
C	B24EE3T03	ELECTRICAL MACHINES II	2-2-0-5	4	4
D	B24EE3T04	INSTRUMENTATION SYSTEMS	3-1-0-5	4	4
E	B24HU3T05	ENTREPRENEURSHIP DEVELOPMENT AND MANAGEMENT STRATEGIES	2-1-0-4	3	3
F	B24EE3P1X	PROGRAMME ELECTIVE I	2-1-0-4	3	3
G	B24EE3L07	MICROPROCESSOR AND MICROCONTROLLER LAB	0-0-3-2	3	2
H	B24EE3L08	POWER ELECTRONICS LAB	0-0-3-2	3	2
M	B24EEM5X	MINOR	3-1-0-5	4	4
N	B24EEH5X	HONOURS	3-1-0-5	4	4
TOTAL*				36	26

Note: Six programme electives are offered starting from Semester 5 as per the curriculum. This curriculum is designed to provide learners with the opportunity to gain proficiency in six different streams of Electrical and Electronics Engineering, including Control and Instrumentation, Power Electronics and Applications, Power System and High Voltage Engineering, Embedded Systems and VLSI, Electronics and Communication Systems, and Intelligent Computing Techniques, through program electives. Learners can choose any one of the streams in semester 5, and it is not compulsory to follow the same stream in the subsequent semesters. The department may offer Elective Courses to enable students to utilize this opportunity, depending on faculty availability.

PROGRAMME ELECTIVE I

COURSE NO.	COURSES
B24EE3P11	BIOMEDICAL INSTRUMENTATION
B24EE3P12	RENEWABLE ENERGY SYSTEMS AND APPLICATIONS
B24EE3P13	HIGH VOLTAGE ENGINEERING
B24EE3P14	MICROCONTROLLERS FOR EMBEDDED SYSTEM DESIGN
B24EE3P15	ELECTRONIC MATERIALS
B24EE3P16	COMPUTER ORGANIZATION AND ARCHITECTURE

SEMESTER 6

SLOT	COURSE NO.	COURSES	L-T-P-S	HOURS	CREDIT
A	B24EE3T05	ADVANCED CONTROL SYSTEM	2-2-0-5	4	4
B	B24EE3T06	ELECTRIC DRIVES AND CONTROL	3-1-0-5	4	4
C	B24EE3T07	POWER SYSTEM II	2-2-0-5	4	4
D	B24EE3T08	OBJECT-ORIENTED PROGRAMMING	2-2-0-5	4	4
E	B24EE3P2X	PROGRAMME ELECTIVE II	2-1-0-4	3	3
F	B24EE3G1X	OPEN ELECTIVE I	2-1-0-4	3	3
G	B24EE3L09	ELECTRICAL MACHINES LAB II	0-0-3-2	3	2
H	B24EE3L10	CONTROL SYSTEMS LAB	0-0-3-2	3	2
M	B24EEM6X	MINOR	3-1-0-5	4	4
N	B24EEH6X	HONOURS	3-1-0-5	4	4
TOTAL*				36	26

PROGRAMME ELECTIVE II

COURSE NO.	COURSES
B24EE3P21	INDUSTRIAL INSTRUMENTATION AND AUTOMATION
B24EE3P22	SWITCHED-MODE POWER CONVERTERS
B24EE3P23	ENERGY MANAGEMENT AND AUDITING
B24EE3P24	SYSTEM DESIGN USING HDL
B24EE3P25	COMMUNICATION SYSTEMS
B24EE3P26	DATA STRUCTURES AND ALGORITHMS

OPEN ELECTIVE I

COURSE NO.	COURSES
B24EE3G11	ELECTRICAL SAFETY
B24EE3G12	RENEWABLE POWER GENERATION SYSTEMS
B24EE3G13	ELECTRICAL POWER UTILIZATION
B24EE3G14	ENERGY MANAGEMENT AND AUDITING
B24EE3G15	INDUSTRIAL AUTOMATION
B24EE3G16	ELECTRIC VEHICLE TECHNOLOGY

SEMESTER 7

SLOT	COURSE NO.	COURSES	L-T-P-S	HOURS	CREDIT
A	B24EE4T01	ELECTRICAL SYSTEM DESIGN AND ESTIMATION	2-1-0-4	3	3
B	B24EE4P3X	PROGRAMME ELECTIVE III	2-1-0-4	3	3
C	B24EE4P4X	PROGRAMME ELECTIVE IV	2-1-0-4	3	3
D	B24EE4G2X	OPEN ELECTIVE II	2-1-0-4	3	3
E	B24HU4T04	DISASTER MANAGEMENT AND INDUSTRIAL SAFETY	2-1-0-4	3	3
G	B24EE4L11	POWER SYSTEMS LAB	0-0-3-2	3	2
H	B24EE4L12	PROJECT PHASE I	0-0-6-2	6	3
J	B24EE4L13	SEMINAR	0-0-4-1	4	2
K	B24EE4T02	VIVA VOCE	0-0-0-0	0	1
M	B24EEM7X	MINOR	3-1-0-5	4	4
N	B24EEH7X	HONOURS	3-1-0-5	4	4
TOTAL*				36	23

PROGRAMME ELECTIVE III

COURSE NO.	COURSES
B24EE4P31	ROBOTICS AND AUTOMATION
B24EE4P32	ELECTRIC VEHICLE TECHNOLOGY
B24EE4P33	POWER QUALITY
B24EE4P34	INTERNET OF THINGS
B24EE4P35	SOLID STATE DEVICES
B24EE4P36	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

PROGRAMME ELECTIVE IV

COURSE NO.	COURSES
B24EE4P41	DIGITAL CONTROL SYSTEM
B24EE4P42	ENERGY STORAGE SYSTEMS FOR EV
B24EE4P43	COMPUTER AIDED POWER SYSTEM ANALYSIS
B24EE4P44	DIGITAL IC DESIGN
B24EE4P45	DIGITAL SIGNAL PROCESSING
B24EE4P46	COMPUTER NETWORKS

OPEN ELECTIVE II

COURSE NO.	COURSES
B24EE4G21	BIOMEDICAL INSTRUMENTATION
B24EE4G22	INTRODUCTION TO ENERGY STORAGE SYSTEMS
B24EE4G23	ILLUMINATION ENGINEERING
B24EE4G24	ARTIFICIAL NEURAL NETWORKS AND FUZZY LOGIC SYSTEMS
B24EE4G25	ELECTRICAL SYSTEM DESIGN FOR BUILDINGS
B24EE4G26	SPECIAL MACHINES

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	B24EE4P5X	PROGRAMME ELECTIVE V	2-1-0-4	3	3
B	B24EE4P6X	PROGRAMME ELECTIVE VI	2-1-0-4	3	3
C	B24EE4G3X	OPEN ELECTIVE III	2-1-0-4	3	3
AND					
H	B24EE4L14	PROJECT PHASE II	0-0-12-3	12	6
M	B24EEML1	MINOR PROJECT	0-0-3-12	3	6
N	B24EEHL1	HONOURS PROJECT	0-0-6-9	6	6
TOTAL*				30	15

PROGRAMME ELECTIVE V

COURSE NO.	COURSES
B24EE4P51	NON-LINEAR CONTROL THEORY
B24EE4P52	ADVANCED ELECTRIC DRIVES
B24EE4P53	POWER SYSTEMS OPERATION AND CONTROL
B24EE4P54	CMOS ANALOG CIRCUIT DESIGN
B24EE4P55	NANOELECTRONICS
B24EE4P56	DEEP LEARNING

PROGRAMME ELECTIVE VI

COURSE NO.	COURSES
B24EE4P61	PROCESS CONTROL AND INSTRUMENTATION
B24EE4P62	POWER CONVERTERS FOR POWER SYSTEM APPLICATIONS
B24EE4P63	SMART GRID TECHNOLOGIES
B24EE4P64	REAL-TIME OPERATING SYSTEMS
B24EE4P65	MICROELECTROMECHANICAL SYSTEMS
B24EE4P66	SOFT COMPUTING TECHNIQUES

OPEN ELECTIVE III

COURSE NO.	COURSES
B24EE4G31	INDUSTRIAL INSTRUMENTATION
B24EE4G32	SUSTAINABLE ENERGY SYSTEMS
B24EE4G33	HUMAN FACTORS ENGINEERING
B24EE4G34	ELECTRICITY MARKETS
B24EE4G35	INTERNET OF THINGS
B24EE4G36	SMART GRID ENGINEERING

PROGRAMME ELECTIVE STREAMWISE LIST

STREAM 1 CONTROL AND INSTRUMENTATION	
ELECTIVE	COURSES
I	BIOMEDICAL INSTRUMENTATION
II	INDUSTRIAL INSTRUMENTATION AND AUTOMATION
III	ROBOTICS AND AUTOMATION
IV	DIGITAL CONTROL SYSTEM
V	NON-LINEAR CONTROL THEORY
VI	PROCESS CONTROL AND INSTRUMENTATION

STREAM 2 POWER ELECTRONICS AND APPLICATIONS	
ELECTIVE	COURSES
I	RENEWABLE ENERGY SYSTEMS AND APPLICATIONS
II	SWITCHED-MODE POWER CONVERTERS
III	ELECTRIC VEHICLE TECHNOLOGY
IV	ENERGY STORAGE SYSTEMS FOR EV
V	ADVANCED ELECTRIC DRIVES
VI	POWER CONVERTERS FOR POWER SYSTEM APPLICATIONS
STREAM 3 POWER SYSTEM AND HIGH VOLTAGE ENGINEERING	
ELECTIVE	COURSES
I	HIGH VOLTAGE ENGINEERING
II	ENERGY MANAGEMENT AND AUDITING
III	POWER QUALITY
IV	COMPUTER AIDED POWER SYSTEM ANALYSIS
V	POWER SYSTEMS OPERATION AND CONTROL
VI	SMART GRID TECHNOLOGIES
STREAM 4 EMBEDDED SYSTEMS AND VLSI	
ELECTIVE	COURSES
I	MICROCONTROLLERS FOR EMBEDDED SYSTEM DESIGN
II	SYSTEM DESIGN USING HDL
III	INTERNET OF THINGS
IV	DIGITAL IC DESIGN
V	CMOS ANALOG CIRCUIT DESIGN
VI	REAL-TIME OPERATING SYSTEMS
STREAM 5 ELECTRONICS AND COMMUNICATION SYSTEMS	
ELECTIVE	COURSES
I	ELECTRONIC MATERIALS
II	COMMUNICATION SYSTEMS
III	SOLID-STATE DEVICES
IV	DIGITAL SIGNAL PROCESSING
V	NANOELECTRONICS
VI	MICROELECTROMECHANICAL SYSTEMS

STREAM 6 INTELLIGENT COMPUTING TECHNIQUES	
ELECTIVE	COURSES
I	COMPUTER ORGANIZATION AND ARCHITECTURE
II	DATA STRUCTURES AND ALGORITHMS
III	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING
IV	COMPUTER NETWORKS
V	DEEP LEARNING
VI	SOFT COMPUTING TECHNIQUES

MINOR

BASKET 1		
SEMESTER	COURSE NO.	COURSES
3	B24EEM31	CIRCUIT THEORY
4	B24EEM41	LINEAR CONTROL SYSTEMS
5	B24EEM51	SYSTEMS THEORY
6	B24EEM61	INDUSTRIAL INSTRUMENTATION AND AUTOMATION
7	B24EEM71	ROBOTICS AND AUTOMATION
8	B24EEM1	MINOR PROJECT
BASKET 2		
SEMESTER	COURSE NO.	COURSES
3	B24EEM32	ELECTRIC CIRCUITS
4	B24EEM42	FUNDAMENTALS OF ELECTRICAL MACHINES
5	B24EEM52	SOLID STATE POWER CONVERSION
6	B24EEM62	POWER ELECTRONIC DRIVES
7	B24EEM72	HVDC TRANSMISSION
8	B24EEM1	MINOR PROJECT
BASKET 3		
SEMESTER	COURSE NO.	COURSES
3	B24EEM33	INTRODUCTION TO POWER ENGINEERING
4	B24EEM43	ENERGY STORAGE SYSTEMS
5	B24EEM53	POWER SYSTEM OPERATION AND CONTROL
6	B24EEM63	POWER SYSTEM AUTOMATION
7	B24EEM73	DISTRIBUTED GENERATION AND SMART GRID
8	B24EEM1	MINOR PROJECT

Note:- Learners can choose any one of the baskets in semester 3, and they have to follow the same basket in the subsequent semesters.

HONOURS

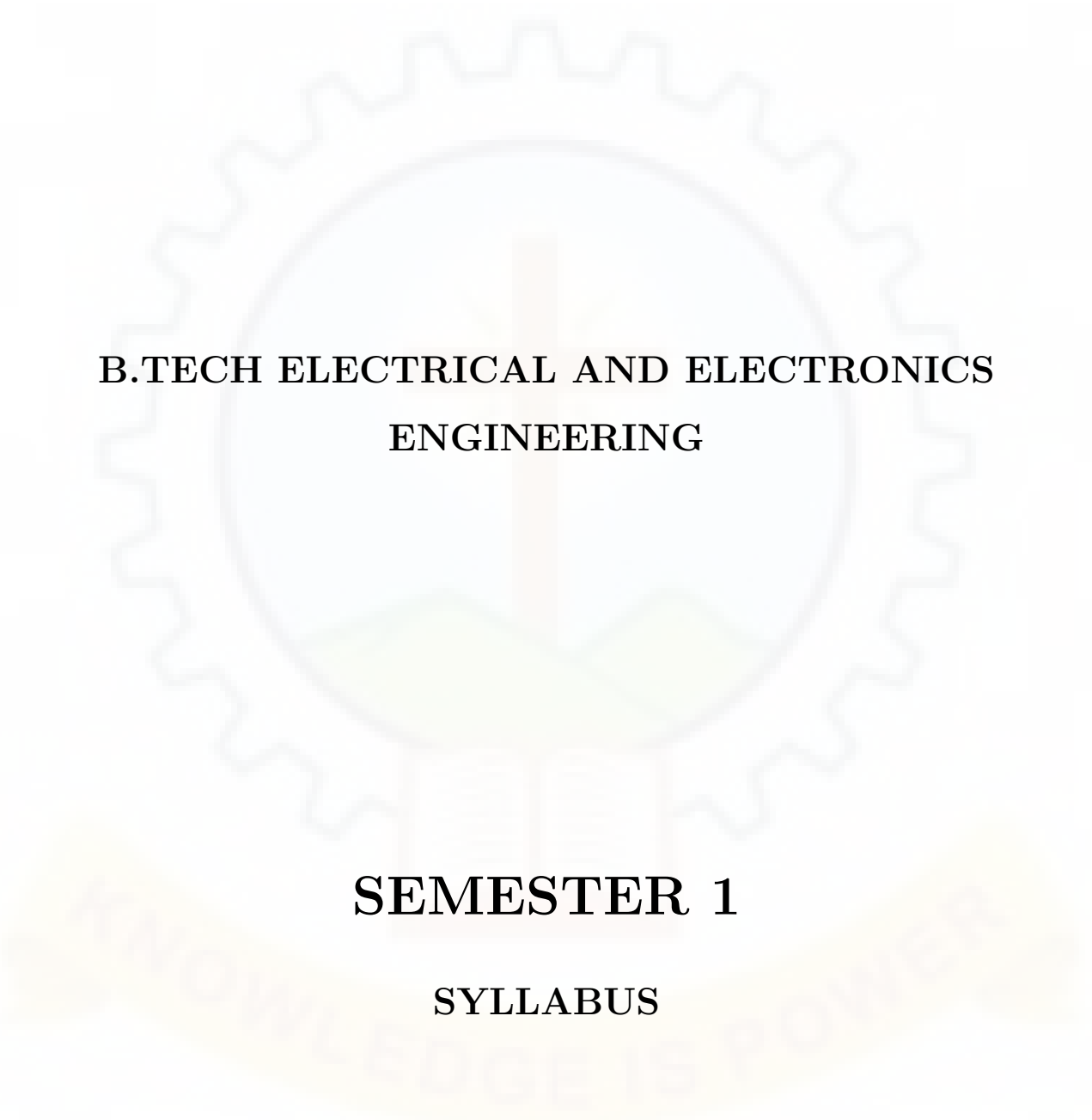
BASKET 1		
SEMESTER	COURSE NO.	COURSES
4	B24EEH41	NETWORK ANALYSIS AND SYNTHESIS
5	B24EEH51	SIMULATION OF ELECTRIC SYSTEMS
6	B24EEH61	ANALYSIS OF POWER ELECTRONIC CIRCUITS
7	B24EEH71	DYNAMICS OF POWER CONVERTERS
8	B24EEHL1	HONOURS PROJECT
BASKET 2		
SEMESTER	COURSE NO.	COURSES
4	B24EEH41	NETWORK ANALYSIS AND SYNTHESIS
5	B24EEH51	SIMULATION OF ELECTRIC SYSTEMS
6	B24EEH62	POWER SYSTEM DYNAMICS
7	B24EEH72	CONTROL AND DYNAMICS OF MICROGRID
8	B24EEHL1	HONOURS PROJECT
BASKET 3		
SEMESTER	COURSE NO.	COURSES
4	B24EEH41	NETWORK ANALYSIS AND SYNTHESIS
5	B24EEH51	SIMULATION OF ELECTRIC SYSTEMS
6	B24EEH63	GENERALIZED MACHINE THEORY
7	B24EEH73	COMPUTATIONAL ELECTROMAGNETICS
8	B24EEHL1	HONOURS PROJECT

Note:- Learners can choose any one of the baskets in semester 4, and they have to follow the same basket in the subsequent semesters.

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**B.TECH ELECTRICAL AND ELECTRONICS
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SEMESTER 1

SYLLABUS

SEMESTER 1

SLOT	COURSE NO.	COURSES	L-T-P-S	HOURS	CREDIT
A	B24MA1T01	LINEAR ALGEBRA AND MULTIVARIABLE CALCULUS	3-1-0-5	4	4
B	B24ES1T01A	PROBLEM SOLVING AND PROGRAMMING TECHNIQUES(A)	2-1-0-4	3	3
C	B24EE1T01	INTRODUCTION TO ELECTRICAL ENGINEERING	2-2-0-5	4	4
D	B24EE1T02	ELECTRONIC CIRCUITS I	2-1-0-4	3	3
E	B24ES1T03B	COMPUTER AIDED ENGINEERING GRAPHICS(B)	2-1-1-5	4	4
G	B24ES1L01A	PROGRAMMING LAB(A)	0-0-3-2	3	2
H	B24EE1L01	BASIC ELECTRICAL ENGINEERING LAB	0-0-3-2	3	2
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	22

B24MA1T01	LINEAR ALGEBRA AND MULTIVARI- ABLE CALCULUS	L	T	P	S	CREDIT	YEAR OF 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.

Prerequisite

Nil

Course Outcomes

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

CO 1	Solve systems of linear equations using matrix methods and determine eigenvalues, eigenvectors and canonical forms of quadratic forms. (Cognitive Knowledge Level: Apply)
CO 2	Calculate partial and total derivatives of multivariable functions and determine their extrema using differential calculus techniques. (Cognitive Knowledge Level: Apply)
CO 3	Apply double and triple integrals to determine areas, volumes, mass and centre of gravity of geometrical regions. (Cognitive Knowledge Level: Apply)
CO 4	Calculate derivatives and line integrals of vector functions and apply them to solve problems in vector calculus. (Cognitive Knowledge Level: Apply)
CO 5	Apply Green's, Stokes' and Divergence theorems to calculate line, surface and flux integrals and model engineering field 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	2	1				1					
CO 3	2	1									
CO 4	2	1									
CO 5	2	1		1	1	1	1				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/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 (9 hours)

Linear Algebra

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), Eigenvalues and eigenvectors. Diagonalization of matrices, orthogonal transformation, quadratic forms and their canonical forms.

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

MODULE 2 (9 hours)

Multivariable Calculus-Differentiation

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.

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

MODULE 3 (9 hours)

Multivariable Calculus-Integration

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).

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

MODULE 4 (9 hours)

Calculus of Vector Functions

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).

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

MODULE 5 (9 hours)

Vector Integral Theorems

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.

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

Text Books

1. H. Anton, I. Biven, S. Davis, *Calculus*, Wiley, 10th ed., 2015.
2. Erwin Kreyszig, *Advanced Engineering Mathematics*, John Wiley & Sons, 10th ed., 2015.

Reference Books

1. G.B. Thomas and R.L. Finney, *Calculus and Analytic Geometry*, Pearson, 9th ed., Reprint, 2002.
2. J. Stewart, *Essential Calculus*, Cengage, 2nd ed., 2017.
3. B.S. Grewal, *Higher Engineering Mathematics*, Khanna Publishers, 43rd., 2015.
4. Peter O Neil, *Advanced Engineering Mathematics*, Thomson, 7th ed., 2007.
5. 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	Module 1: Linear Algebra	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	Eigenvalues and eigenvectors	2
1.4	Diagonalization of matrices	2
1.5	Orthogonal transformation, quadratic forms and their canonical forms	2

2	Module 2: Multivariable Calculus-Differentiation	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	Module 3: Multivariable Calculus-Integration	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	Module 4: Calculus of Vector Functions	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	Module 5: Vector Integral Theorems	9
5.1	Green's theorem and its 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, diagonalise matrices and characterise quadratic forms.

1. A is a real matrix of order 3×3 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

$$X = \begin{bmatrix} 1 \\ 2 \\ -1 \end{bmatrix}. \text{ Find } A^5 X.$$

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 its 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 marks)
- (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 marks)

OR

12. (a) Diagonalize the matrix $\begin{bmatrix} -1 & 2 & -2 \\ 2 & 4 & 1 \\ 2 & 4 & 1 \end{bmatrix}$ (7 marks)
- (b) What kind of conic section the quadratic form $3x^2 + 22xy + 3y^2 = 0$ represents? Transform it to principal axes. (7 marks)
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 marks)
- (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 marks)

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 marks)
- (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 marks)
15. (a) Evaluate $\iint_D (2x^2y + 9y^3) dx dy$ where D is the region bounded by $y = \frac{2}{3}x$ and $y = 2\sqrt{x}$. (7 marks)
- (b) Evaluate $\int_0^4 \int_{\sqrt{y}}^2 e^{x^3} dx dy$ by changing the order of integration. (7 marks)

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 marks)
- (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 marks)
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 marks)

- (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 marks)

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 marks)
- (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 marks)
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 marks)
- (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 marks)

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 marks)
- (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 marks)

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	3	3		1	1	1	1	1	1
CO 2	3	3	3	3		1	1	1		1	1
CO 3	3	3	3	3		1	1	1		1	1
CO 4	3	3	3	3		1	1	1		1	1
CO 5	3	3	3	3		1	1	1		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 (5 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. Stephen C. Kochan, *Programming in C*, CBS Publishers.
2. E. Balaguruswamy, *Programming in C*, Mc Graw Hill.
3. Yashwant Kanetkar, *Let us C*, BPB Publications.
4. Al Kelley and Ira Pohl, *A Book on C*, Addison-Wesley.
5. Stan Kelly Bootle, *Mastering Turbo C*, BPB Publications.
6. Yashwant Kanetkar, *Pointers in C*, BPB Publications.
7. Munish Cooper, *The Spirit of C*, Jaico Books.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: C Fundamentals	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
	Module 2: Control Statements	9
2.1	Control statements: if, if-else, nested if	

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
	Module 3: Strings and Functions	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
	Module 4: Structures	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
	Module 5: Files	5
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()	1
5.4	Library functions related to file – fread(), fwrite()	1
5.5	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 marks)

OR

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

OR

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

OR

16. (a) What is the purpose of function declaration and function definition and function call? With examples illustrate their syntax. (7 marks)
(b) What is recursion? Write a C program to display Fibonacci series using recursive function. (7 marks)
17. (a) Write a C program to: (7 marks)
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 marks)

OR

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

OR

20. (a) Write a C program to count number of lines in a text file. (7 marks)
(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 marks)

B24EE1T01	INTRODUCTION TO ELECTRICAL ENGINEERING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	2	0	5	4	2024

Preamble

The course aims to equip the students with an understanding of the fundamental principles of electrical engineering. This will set a strong conceptual understanding of basic electrical laws and theorems with the art of technical problem solving. Upon successful completion of the course, the students will be empowered to analyze and comprehend the diverse electrical systems that surround us.

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 electric circuits. (Cognitive Knowledge Level: Apply)
CO 2	Apply the circuit theorems of electrical engineering to solve DC circuits in steady-state. (Cognitive Knowledge Level: Apply)
CO 3	Understand the basic concepts of magnetism to develop and solve models of magnetic circuits and fundamental concepts of AC systems. (Cognitive Knowledge Level: Understand)
CO 4	Solve single-phase AC circuits by applying the fundamental laws of electrical engineering and analyze the same using circuit theorems. (Cognitive Knowledge Level: Apply)
CO 5	Analyze balanced and unbalanced 3-phase star-connected and delta-connected systems. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	1	2	1		1	1		2
CO 2	3	2	1	1	2	1		1	1		2
CO 3	3	2	1	1	2	1		1	1		2
CO 4	3	2	1	1	2	1		1	1		2
CO 5	3	2	1	1	2	1		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/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 (10 hours)

DC Circuits

Independent voltage and current sources, passive components (circuit and dimension), Ohm's Law, Kirchhoff's Laws, series and parallel combinations, voltage and current division rule, Star-Delta/Delta-Star Conversions to reduce resistive networks, source transformation.

Analysis of DC Circuits

Mesh current analysis and nodal voltage analysis of circuits containing resistors and independent sources- solution of network equations by matrix representation.

MODULE 2 (8 hours)

Circuit Theorems

Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum Power Transfer theorem, and Reciprocity theorem. Thevenin's and Norton's equivalent circuits (with independent sources only).

MODULE 3 (12 hours)

Electromagnetism

Magnetism - Terminologies, analogy of electrical and magnetic circuit, series and parallel magnetic circuits, force on current carrying conductors placed in a magnetic field - Fleming's left-hand rule, Faraday's Laws of electromagnetic induction, Lenz's Law, statically and dynamically induced EMF - self-inductance, mutual-inductance and coefficient of coupling.

AC Fundamentals

Generation of sinusoidal voltage and currents, average value, rms value, form and peak factors of trapezoidal and sinusoidal waveforms, Phasor representation of sinusoidal quantities - phase difference, addition and subtraction of sinusoids, Symbolic Representation: cartesian, polar and exponential forms.

MODULE 4 (8 hours)

Single Phase AC Circuits

AC circuits with pure resistance, pure inductance, pure capacitance, RL, RC, and RLC circuits - voltage-current phasor diagrams, active, reactive, apparent, complex power, and power factor.

Circuit Theorems in AC

Thevenin's Theorem, Norton's Theorem, and Maximum Power Transfer Theorem.

MODULE 5 (7 hours)

Analysis of Three-phase AC Circuits

Generation of 3-phase AC voltage, phase sequence, 3-phase star connected and delta connected systems - balanced and unbalanced 3-wire and 4-wire systems, power in three-phase balanced circuits - active power, reactive power, complex power, apparent power and power factor.

Text Books

1. K. S. Suresh Kumar, *Electric Circuits and Networks*, Pearson Education, 2nd ed., 2022.
2. B. L. Theraja, *Electrical Technology*, S. Chand Publication, Vol.1, 30th ed., 2020.
3. V. K. Mehta, *Basic Electrical Engineering*, S. Chand and Company Ltd, 8th ed., 2020.
4. Edward Hughes, *Electrical Technology*, Pearson Education, 11th ed., 2020.
5. J. A. Edminister, *Electric Circuit Theory*, McGraw-Hill, 2nd ed., 2022.

Reference Books

1. Del Toro V, *Electrical Engineering Fundamentals*, Pearson Education, 3rd ed., 2023.
2. T. K. Nagsarkar, M. S. Sukhija, *Basic Electrical Engineering*, Oxford Higher Education, 6th ed., 2022.
3. Hayt W. H., Kemmerly J. E., and Durbin S. M., *Engineering Circuit Analysis*, Tata McGraw-Hill, 10th ed., 2023.
4. Hughes, *Electrical and Electronic Technology*, Pearson Education, 12th ed., 2022.
5. V. N. Mittle and Arvind Mittal, *Basic Electrical Engineering*, McGraw Hill, 6th ed., 2022.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: DC Circuits and Analysis of DC Circuits	10
1.1	Independent voltage and current sources, passive components (circuit and dimension), Ohm's Law, Kirchhoff's Laws	1
1.2	Series and parallel combinations, voltage, and current division rule -Numerical problems	2
1.3	Star-Delta / Delta-Star Conversions to reduce resistive networks (derivation not required), source transformation-Numerical problems	2
1.4	Mesh current analysis and nodal voltage analysis of circuits containing resistors and independent sources	2
1.5	Numerical problems	1
1.6	Solution of network equations by matrix representation	2
	Module 2: Circuit Theorems	8
2.1	Superposition theorem, Numerical problems	2
2.2	Maximum Power Transfer theorem, and Reciprocity Theorem. Numerical problems	2
2.3	Thevenin's theorem and Norton's theorem	1
2.4	Determination of Thevenin's and Norton's equivalent circuits containing independent sources	3
	Module 3: Electromagnetism and AC Fundamentals	12
3.1	Magnetism- Terminologies, analogy of electrical and magnetic circuit, series and parallel magnetic circuits - Numerical problems	2
3.2	Force on current carrying conductors placed in a magnetic field - Fleming's left-hand rule	1
3.3	Faraday's Laws of electromagnetic induction, Lenz's Law, statically and dynamically induced EMF	2
3.4	Self-inductance, mutual-inductance, and coefficient of coupling- Numerical problems	2
3.5	Generation of sinusoidal voltage and currents	1
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
	Module 4: Single phase AC Circuits and Circuit Theorems in AC	8

4.1	AC circuits with pure resistance, pure inductance, pure capacitance, RL, RC, and RLC circuits -corresponding voltage-current phasor diagrams	2
4.2	Active, reactive, apparent, complex power, and power factor	1
4.3	Numerical problems	3
4.4	Thevenin's theorem, Norton's theorem, and Maximum Power Transfer Theorem for AC circuits - Numerical problems	2
	Module 5: Analysis of Three-phase AC Circuits	7
5.1	Generation of 3-phase AC voltage, phase sequence	1
5.2	3-phase star connected and delta connected systems- balanced and unbalanced - 3-wire and 4-wire systems - Numerical problems	3
5.3	Power in three-phase balanced circuits- active power, reactive power, complex power, apparent power and power factor Numerical problem	3

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Solve problems based on the current division rule.
2. Solve problems with Mesh/Nodal analysis.
3. Solve problems on Star-Delta Transformation.

Course Outcome 2 (CO 2)

1. Solve DC circuits using the Superposition theorem.
2. Solve DC circuits using the Maximum Power Transfer/Reciprocity Theorem.
3. Determination of Thevenin's and Norton's equivalent circuits.

Course Outcome 3 (CO 3)

1. Problems on series/parallel magnetic circuits.
2. Problems on self-inductance, mutual-inductance, and coefficient of coupling.
3. Problems on rms and average values of periodic waveforms.

Course Outcome 4 (CO 4)

1. Problems on series RL and RC circuit.
2. Problems on series RLC circuit.
3. Solve AC circuits using Thevenin/Norton's Theorem.

Course Outcome 5 (CO 5)

1. Solve problems of balanced 3-phase star and delta connected system.
2. Solve problems of unbalanced 3-phase star and delta-connected system.
3. Determination of power in three-phase balanced circuits.

MODEL QUESTION PAPER

QP CODE:

Pages: 4

Reg.No.:

Name:

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),
KOTHAMANGALAM

FIRST SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: : B24EE1T01

Course Name: : INTRODUCTION TO ELECTRICAL ENGINEERING

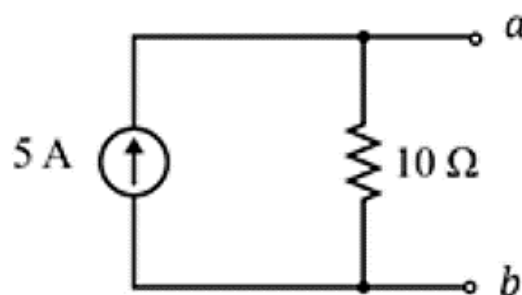
Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. State Kirchhoff's laws. Draw a circuit with one loop consisting of two resistances and two voltage sources, and write the voltage equation of the loop.
2. Three resistors, $20\ \Omega$, $90\ \Omega$, and $10\ \Omega$, are star connected. Obtain the equivalent delta circuit.
3. State and explain the Reciprocity theorem using an example.
4. Find the value of the load resistance to be connected at a - b so that maximum power is transferred by the source. What is the maximum power delivered to the load?



5. Distinguish between self and mutual inductances. Derive an expression for the self-inductance of a coil.
6. Derive the form factor of a pure sinusoidal waveform.

7. A resistance of $10\ \Omega$ and an inductive reactance of $10\ \Omega$ are connected in series. Calculate the value of impedance and draw the impedance triangle.
8. Explain active power, reactive power, and apparent power.
9. Draw a three-phase, four-wire system and mark the voltage between each wire. Assume that the voltage across a phase is 230 V.
10. Derive the relation between line and phase values of voltage and current for delta connected system.

PART B

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

11. (a) Determine the node voltages in the Figure 1. (10 marks)

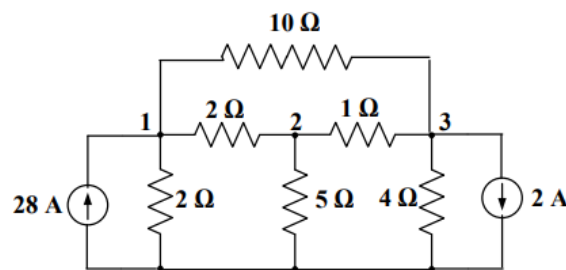


Figure 1

- (b) Three lamps are connected in series across a 180 V supply and take a current of 2.5 A. If the resistance of two of the lamps is $30\ \Omega$ each, what is the resistance of the third lamp? (4 marks)

OR

12. (a) Using mesh analysis, find the voltage V_x of Figure 2. (10 marks)

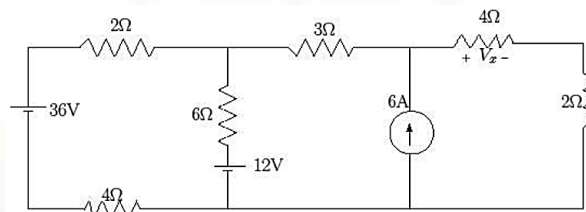


Figure 2

- (b) Using star delta transformation, find the equivalent resistance between A and B in Figure 3. (4 marks)

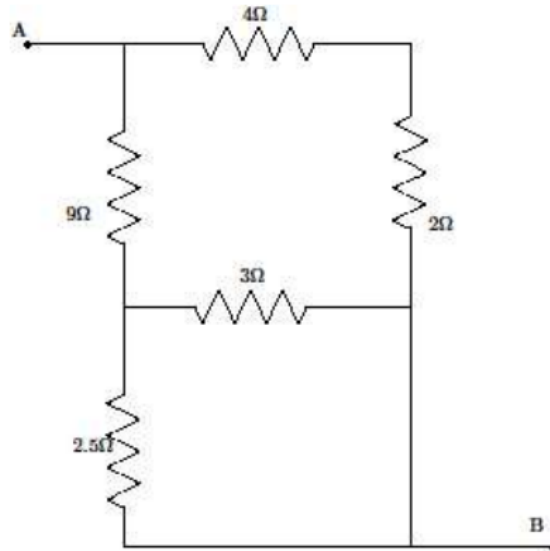


Figure 3

13. For the circuit given in Figure 4,

- (a) Determine the Thevenin's equivalent circuit across the terminals X and Y. (10 marks)
- (b) Determine the value of resistance to be connected across X and Y so that maximum power is transferred to it. Also, calculate the maximum power transferred. (4 marks)

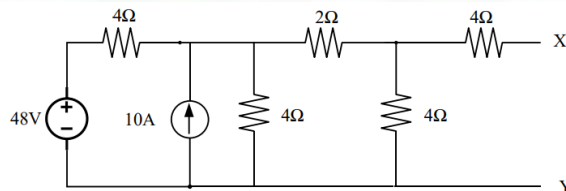


Figure 4

OR

14. For the circuit given in Figure 5, apply the superposition theorem to find the power dissipated in the 5 Ω. (14 marks)

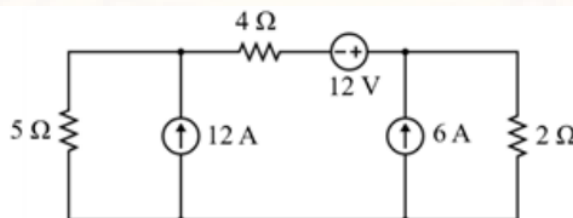


Figure 5

15. (a) A magnetic core is made up of a ring with a mean diameter of 7.96 cm and a cross-sectional area of 1 cm^2 . The relative permeability of iron is 2000. A coil of

1500 turns is uniformly wound around the ring. Obtain the current required to produce a flux of 25 mWb? What current will be required to maintain the same flux, if an air gap of 2 mm is cut through the core. (10 marks)

- (b) Write a short note on (4 marks)
- Magneto motive force
 - Reluctance
 - Magnetic flux
 - Permeability

OR

16. (a) Define the following terms with an example: a) Phase b) Phase difference. (4 marks)
- (b) Explain in detail the dynamically and statically induced emfs. An air solenoid has 300 turns, its length is 25 cm, and cross-sectional area of 3 cm^2 . Calculate the self-inductance. If the coil current of 10 A is completely interrupted in 0.04 s, calculate the induced emf in the coil. (10 marks)
17. (a) A current of 5 A flows through a non-inductive resistance in series with a choke coil when supplied at 250 V, 50 Hz. If the voltage across the resistance is 125 V and that across the coil is 200 V, calculate (i) Impedance, reactance, and resistance of the coil, (ii) Power absorbed by the coil, and (iii) Total power absorbed by the circuit. (10 marks)
- (b) Explain the phasor diagram and impedance triangle of a series resistive inductive circuit excited by an AC source. (4 marks)

OR

18. In the circuit given in Figure 6,

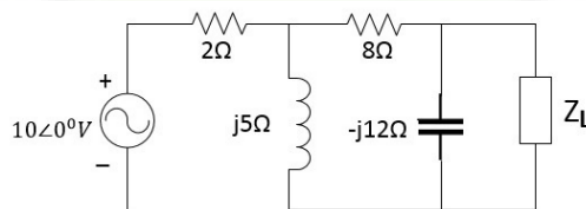


Figure 6

- (a) Determine the value of the load impedance for maximum power transferred by the source to the load. (12 marks)
- (b) Find the maximum power transferred. (2 marks)
19. A 3-phase, 3-wire, 240V system supplies a delta-connected load in which $Z_{AB} = 25 \angle 90^\circ \Omega$, $Z_{BC} = 15 \angle 30^\circ \Omega$ and $Z_{CA} = 20 \angle 0^\circ \Omega$. Determine the phase currents, line currents, and total power consumed by the load. (14 marks)

OR

20. A 3-phase, 400V, 4-wire system has a star connected load with $Z_A = 20 \Omega$, $Z_B = 15 + j10 \Omega$ and $Z_C = j5 \Omega$. Find the line currents, current through the neutral conductor, and the total power consumed by the load. (14 marks)

B24EE1T02	ELECTRONIC CIRCUITS I	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Electronic Circuits I course aims to impart sound knowledge and basic concepts of electronic circuits. It gives information about the principle of operation of electronic devices and their practical applications. This course will enable the students to understand and analyse practical electronic circuits.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the fundamental concepts of diodes, applications, and analysis. (Cognitive Knowledge Level: Understand)
CO 2	Describe the various transistor configurations and characteristics. (Cognitive Knowledge Level: Apply)
CO 3	Apply the basic biasing and stabilization techniques of transistors to develop practical circuits. (Cognitive Knowledge Level: Apply)
CO 4	Apply the h parameter model to find amplifier parameters and understand the frequency response of multi-stage amplifiers. (Cognitive Knowledge Level: Apply)
CO 5	Understand the principles of power amplifiers and various oscillators. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	3		1		1				1
CO 2	3	3	3		1		1				1
CO 3	3	3	3	1	1		1				1
CO 4	3	3	3	1	1		1				1
CO 5	3	3	3	1	1		1				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/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)

Introduction to Semiconductor Devices

PN Junction diode - principle of operation, VI characteristics, principle of avalanche break-down, zener diode, zener shunt regulator, Schottky diode.

Rectifiers

Half-wave rectifier, full-wave rectifier, full-wave bridge rectifier-design of half-wave and full-wave rectifiers with capacitor filters.

MODULE 2 (8 hours)

Wave Shaping Circuits

Clipping circuits and clamping circuits - applications - RC Integrator and Differentiator.

Transistor Circuits

Bipolar Junction Transistors (BJT), PNP and NPN structures, principle of operation, the relation between current gains in CE, CB, and CC, input and output characteristics of common base and common emitter configuration. Uni Junction Transistor (UJT), Junction Field Effect Transistor (JFET) - construction and working principle.

MODULE 3 (7 hours)

Transistor Stability

Operating point of BJT - factors affecting stability of Q point, DC biasing - biasing circuits - fixed bias, collector to base bias, voltage divider bias, role of emitter resistance in bias stabilization - stability factor derivation for voltage divider biasing, Numerical problems.

MODULE 4 (8 hours)

h-parameters

Modeling of BJT - h-parameter model of BJT in CE configuration, small signal low frequency, AC equivalent circuit of CE amplifier, calculation of amplifier gains and impedances using h-parameter equivalent circuit - Numerical problems.

Feedback in Amplifiers: Effect of positive and negative feedback.

Multistage Amplifiers

Direct coupled amplifiers, RC coupled amplifiers, frequency response of RC coupled - role of coupling capacitors and emitter bypass capacitor.

MODULE 5 (6 hours)

Power Amplifiers using BJT

Class A, Class B, Class AB, Class C, and Class D amplifiers (basic principles).

Oscillators

Oscillators: Barkhausen's criterion - RC phase shift oscillator, LC oscillators (Hartley), Crystal oscillator (derivation not needed), BJT sweep generator, Astable multivibrator (working principle and applications only).

Text Books

1. Bell D. A., *Electronic Devices and Circuits*, Oxford University Press, 5th ed., 2007.
2. Boylestad R. L. and L. Nashelsky, *Electronic Devices, and Circuit Theory*, Pearson Education, 10th ed., 2009.
3. Floyd T.L., *Fundamentals of Analog Circuits*, Pearson Education, 2nd ed., 2012.

Reference Books

1. J. B. Gupta, *Electronic Devices and Circuits*, S.K. Kataria, 6th ed., 2016.
2. Millman J. and C. C. Halkias, *Integrated Electronics: Analog and Digital Circuits and Systems*, Tata McGraw-Hill, 2nd ed., 2010.
3. Malvino A. and D. J. Bates, *Electronic Principles*, Tata McGraw Hill, 7th ed., 2010.
4. Allen Mottershead, *Electronic Devices and Circuits: An Introduction*, Prentice Hall of India.
5. G.K. Mithal, *Electronic Devices and Circuits*, Khanna Publishers, 2014.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Introduction to Semiconductor Devices	7
1.1	PN Junction diode, principle of operation, VI characteristics	1
1.2	Principle of avalanche breakdown - Zener diode	1
1.3	Zener shunt regulator, Schottky diode	1
1.4	Rectifiers - Half-wave rectifier, Full-wave rectifier	2
1.5	Full-wave bridge rectifier	1
1.6	Design of Half-wave and full-wave rectifiers with capacitor filters	1
	Module 2: Wave Shaping Circuits and Transistor Circuits	8
2.1	Clipping circuits	1
2.2	Clamping circuits - Applications- RC Integrator and Differentiator	2
2.3	Transistor circuits - Bipolar Junction Transistors	1
2.4	PNP and NPN structures, principle of operation	1
2.5	Relation between current gains in CE, CB, and CC	1
2.6	Input and output characteristics of common base and common emitter configuration	1
2.7	UJT and JFET - construction and working principle	1
	Module 3: Transistor Stability	7
3.1	Operating point of BJT - Factors affecting the stability of Q point	2
3.2	DC Biasing circuits - fixed bias, collector to base bias	1
3.3	Voltage divider bias, role of emitter resistance in bias stabilization	1
3.4	Stability factor derivation for Voltage Divider Biasing	1
3.5	Numerical problems – Biasing	2
	Module 4: h-parameters and Multistage Amplifiers	8
4.1	Introduction to h-parameters	1
4.2	Modeling of BJT- h-parameter model of BJT in CE configuration	1
4.3	Small signal low-frequency AC equivalent circuit of CE amplifier	1
4.4	Calculation of amplifier gains and impedances using the h-parameter equivalent circuit, Numerical problems	2
4.5	Feedback in Amplifiers - Effect of positive and negative feedback	1

4.6	Multistage amplifiers: Direct coupled amplifiers, RC coupled amplifiers, the frequency response of RC coupled amplifier, Role of coupling capacitors, and emitter bypass capacitor	2
	Module 5: Power Amplifiers using BJT and Oscillators	6
5.1	Power amplifiers using BJT: Class A, Class B, Class AB, Class C, and Class D amplifiers	2
5.2	Oscillators: Barkhausen's criterion - RC Phase Shift oscillator (principle and frequency of operation)	1
5.3	LC oscillators (Hartley), Crystal oscillator (derivation not needed)	1
5.4	BJT Sweep generator (working principle and applications only)	1
5.5	Astable multivibrator (working principle and applications only)	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the principle of operation of the diode.
2. Draw the VI characteristics of diodes.
3. Explain the working of rectifiers.

Course Outcome 2 (CO 2)

1. Understand the working of clipping and clamping circuits.
2. Explain the different configurations of transistors.
3. Describe the operation of UJT and JFET.

Course Outcome 3 (CO 3)

1. Problems with the stability factor of voltage divider biasing.
2. Explain factors affecting stability of Q point.
3. Explain the various biasing circuits and compare them.

Course Outcome 4 (CO 4)

1. Problems on amplifier gains and impedances using h-parameter equivalent.
2. Compare positive and negative feedback in amplifiers
3. Explain the frequency response curve of the RC coupled amplifier.

Course Outcome 5 (CO 5)

1. What are the various classes of Power Amplifiers?
2. Explain the working principle of Oscillators.
3. Explain the working of the Sweep Generator and Astable Multivibrator.

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: B24EE1T02

Course Name: ELECTRONIC CIRCUITS I

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Differentiate between Avalanche and Zener breakdown.
2. Explain the principle of Schottky diode.
3. Design a suitable circuit to obtain the output level clipped at +3V and -4V for a 10V peak-to-peak sinusoidal input voltage.
4. With a neat diagram, explain the constructional features of n channel JFET.
5. What are the advantages of potential divider biasing?
6. State the functions of a transistor biasing circuit.
7. Draw and explain the frequency response characteristics of the RC coupled amplifier.
8. List out the advantages of negative feedback in amplifiers.
9. Explain the Barkhausen's criteria of oscillations.
10. Draw the circuit of crystal oscillator.

PART B

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

11. (a) Explain the working of a PN junction diode and draw the VI characteristics of the diode. (8 marks)
(b) Explain the formation of potential barrier in a PN junction diode. (6 marks)

OR

12. (a) With a neat diagram, explain the working of a full wave bridge rectifier. (8 marks)
(b) Narrate how the capacitor filter eliminates ripples from the output of a rectifier. (6 marks)
13. (a) Explain the working of an NPN transistor. Describe with suitable sketches the input and output characteristics of a common emitter NPN transistor. (10 marks)
(b) Derive the relationship between common base current gain and common emitter current gain. (4 marks)

OR

14. (a) With a neat circuit diagram, explain the working of a negative voltage clamping circuit. (8 marks)
(b) Explain the working of a Uni Junction Transistor. (6 marks)
15. (a) Define the stability factor and derive the equation for the stability factor for voltage divider biasing. (8 marks)
(b) What factors are to be considered for selecting the operating point Q of an amplifier? (6 marks)

OR

16. Design a voltage divider bias circuit to operate from an 18 V supply in which bias conditions are to be $V_{CE} = V_E = 6$ V, $I_C = 1.5$ mA, and $\beta = 90$. Also, calculate the stability factor S. (14 marks)
17. (a) Derive the equation for voltage gain and current gain for a BJT using an approximate h-parameter model for common emitter configuration. (8 marks)
(b) Given h-parameters of a transistor connected in CE configuration is $h_{ie} = 1000 \Omega$, $h_{re} = 10 \times 10^{-4}$, $h_{fe} = 50$, $h_{oe} = 100 \times 10^{-6}$. If the load resistance R_L is 1 K Ω , find i) Input impedance, ii) Current gain, and iii) Voltage gain. (6 marks)

OR

18. (a) Draw the h parameter model of a transistor in CE configuration. Also, derive the expression for input impedance, current gain, and voltage gain. (8 marks)
- (b) Describe the gain and bandwidth of an RC-coupled amplifier. (6 marks)
19. (a) With a neat diagram, explain the working of a Hartley Oscillator. (8 marks)
- (b) Explain the working of Class A amplifier. (6 marks)

OR

20. (a) With a neat diagram, explain the working of the Astable multivibrator. (8 marks)
- (b) Explain the working of the Class C amplifier. (6 marks)

B24ES1T03B	COMPUTER AIDED ENGINEERING GRAPHICS(B)	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	1	5	4	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

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

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 be from Part A having 20 marks and test 2 will be from Part B with 20 marks. Regarding Assignments/Class work, 15 marks will be awarded for Part A and remaining 25 marks should be based on class works/assignments from Part B (minimum 5 exercise).

End Semester Examination Pattern

ESE will be from Part A of 2-hour duration on A4 size answer booklet and will be for 50 marks.

The question paper shall contain two parts, in which Part I contains one question from each module, each carries 12 marks and Part II contains two questions from any of the three modules carrying 14 marks each. 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

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 (5 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.

Use of CAD tools to draw simple electrical components and circuits. Drawing of simple electrical line drawings, layouts etc..

MODULE 5 (9 hours)

Isometric Projection using CAD

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

Simple isometric and Orthographic views of electrical components.

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., 54th ed., 2023.
2. John, K.C. *Engineering Graphics*, Prentice Hall India, 2nd ed., 2009.
3. K.N. Anilkumar, *Engineering Graphics*, Adhyuth Narayan, 8th ed., 2013.
4. P. I. Varghese, *Engineering Graphics*, VIP, 34th ed., 2023.

Reference Books

1. Agrawal, B. and Agrawal, C.M., *Engineering Drawing*, Tata McGraw Hill Publishers, 3rd ed., 2019.
2. Duff, J.M. and Ross, W.A., *Engineering Design and Visualisation*, Cengage Learning, 1st ed., 2008.
3. Kulkarni, D.M., Rastogi, A.P. and Sarkar, A.K., *Engineering Graphics with AutoCAD*, Prentice Hall India, 1st ed., 2010.

4. Luzaddff, W.J. and Duff, J.M., *Fundamentals of Engineering Drawing*, Prentice Hall India, 1st ed.,1992.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Introduction and Orthographic Projection of Points and Lines	11
1.1	Introduction: 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
	Module 2: Orthographic projection of Solids	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
	Module 3: Sections of Solids and Development of Surfaces	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
	Module 4: Introduction to Computer Aided Drawing	5
4.1	Introduction to Computer Aided Drawing: 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 and oops, Copy and Move objects, Rotate, Scale, Stretch Extend and Offset, Mirror and array, Apply Chamfers and Fillets, Edit polylines and spline, decurve, fit, thickness join and explode	1
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	1
4.5	Use of CAD tools to draw simple electrical components and circuits. Drawing of simple electrical line drawings, layouts etc.	1
	Module 5: Isometric Projection using CAD and Conversion of Pictorial Views using CAD	9
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	Simple isometric and orthographic views of electrical machines	1
5.4	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.
2. Draw simple electrical components and circuits using 2D software.

Course Outcome 5 (CO 5)

1. Draw Isometric views/projections of solids or combination of solids using modelling software.
2. Draw simple Isometric views/projections of electrical components using modelling software.
3. 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

FIRST SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: B24ES1T03B

Course Name: COMPUTER AIDED ENGINEERING GRAPHICS(B)

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 endpoint A of a line is 20 mm above HP and 10mm in front of VP. The other end of the line is 50 mm above HP and 15 mm behind VP. The distance between the end projectors is 70 mm. 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 25 mm and height 40 mm, is resting on the ground on one of its triangular faces. The base edge of that face is inclined 30^0 to VP. Draw the projections of the solid.
3. Draw the development of a pentagonal pyramid of base side 30 mm and height 50 mm. 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 40 mm and height 70 mm 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 30 mm and 10 mm. 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 35^0 to HP and the base edge at which it is resting is inclined 40^0 to VP.

B24ES1L01A	PROGRAMMING LAB(A)	L	T	P	S	CREDIT	YEAR OF 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

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

Mark Distribution

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

Continuous Internal Evaluation Pattern

Attendance	10 marks
Continuous Assessment	20 marks
Viva-Voce/ Test	15 marks
Lab Record	5 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. a) Write a C program to display the personal details. b) Write a C program to add two numbers. c) Write a C program to evaluate the arithmetic expression using command line arguments.
3	Familiarization of Operators. a) Write a C program to evaluate bitwise operations on given numbers. b) Write a C program to swap two numbers using XOR operation. 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 a) To read an array of size n and display in reverse order. 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 a) Read a matrix. b) Find the sum of two matrices. c) Find the product of two matrices. d) Find the transpose of a matrix. 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 a) Add two numbers. b) Swap two numbers using a user defined function.
23	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.
24	Define a structure for student with fields roll no, name and age. Create a pointer to this structure, assign values to the fields, and print the values using pointer.
25	Write a C program to concatenate two strings using pointers.
26	Create a file and perform the following a) Write data to the file. b) Read the data in a given file & display the file content on console. c) Append new data and display on console.
27	Open a text file and count the number of characters, words and lines in it; and store the result in another file.
28	Find the substring from the given text file and replace it with another string.

Reference Books

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

B24EE1L01	BASIC ELECTRICAL ENGINEERING LAB	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

The basic electrical lab aims to equip students with practical experience and a comprehensive understanding of fundamental electrical engineering principles. This includes learning the safe use of electrical equipment, understanding circuit components, and applying theoretical knowledge to practical scenarios. Upon successful completion of the course, the students will be well-prepared to connect theoretical knowledge with practical application, fostering a deeper understanding of electrical engineering principles.

Prerequisite

Nil

Course Outcomes

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

CO 1	Identify electrical symbols, measuring instruments, accessories, and tools used for electrical wiring, and perform basic electrical wiring. (Cognitive Knowledge Level: Understand)
CO 2	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)
CO 3	Apply fundamental circuit theorems to various electrical circuits. (Cognitive Knowledge Level: Apply)
CO 4	Measure various circuit parameters and analyze the voltage-current relationship of RLC circuits, linear and non-linear loads. (Cognitive Knowledge Level: Apply)
CO 5	Develop team management skills and prepare laboratory reports that logically and scientifically communicate experimental information. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Mark Distribution

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

Continuous Internal Evaluation Pattern

Attendance	10 marks
Continuous Assessment	20 marks
Performance	15 marks
Viva-Voce	5 marks
Lab Record	5 marks
Internal Exam	15 marks

End Semester Examination (ESE) Pattern:

The following guidelines should be followed regarding the award of marks

1. Preliminary work : 25 Marks
 - (a) Circuit Diagram: 15 Marks
 - (b) Theory and Procedure: 10 Marks
2. Implementing the work/Conducting the experiment : 30 Marks (usage of equipment and troubleshooting)
3. Result and Inference : 15 Marks
4. Viva Voce : 30 Marks

SYLLABUS

LIST OF EXPERIMENTS

1	a) Familiarization with electrical symbols, measuring instruments, lighting and wiring accessories, tools, and various wiring systems. b) Study the electric shock phenomenon, precautions, safety procedures, and earthing in electrical installations.
2	Realization of domestic wiring a) Wiring of one lamp controlled by one switch and a 3-pin plug socket controlled independently. b) Wiring of one lamp controlled by two switches (Staircase wiring).
3	a) Realization of Industrial wiring - Wiring of three lamps controlled by three switches (Godown wiring). b) Study of fuse, MCB, ELCB, and selection and rating of fuse, MCB, ELCB for circuits with medium and high power.
4	Wiring of the distribution board, including the power plug, an isolator, MCB, and ELCB for 1000 W power.
5	Measurement of low-medium-high resistance using the Megger and voltmeter-ammeter method.
6	Visit the on-campus substation and familiarize with the supply system, transformer, HT Panel, and distribution system.
7	a) Determination of V-I characteristics of the linear resistor and linear inductor, incandescent, and LED lamps. b) Verification of KCL and KVL for the given circuit theoretically and experimentally.
8	Verification of the Superposition theorem and Thevenin's theorem for the given circuit theoretically and experimentally.

9	Verification of Reciprocity's theorem and Maximum Power Transfer theorem for the given circuit theoretically and experimentally.
10	a) Measurement of self-inductance, the mutual inductance, and the coupling coefficient of two coils. b) Verification of the relation between phase and line quantities in a 3-phase balanced star and delta connected systems.
11	Analyze the RLC series and parallel AC circuits and verify them experimentally.
12	a) Determine the current and voltage response under illumination depending on the magnitude of the variable resistance. b) Visit the on-campus 150 kW solar power plant.

Reference Books

1. H. Cotton, *Advanced Electrical Technology*, Reem Publications, 5th ed., 2011.
2. K. S. Suresh Kumar, *Electrical Circuit and Networks*, Pearson Education, 2009.
3. E. W. Golding, *Electrical Measurements and Measuring Instruments*, Pitman, 3rd ed., 2011.

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
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
100	50	50

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*, Wiley Publishing Ltd, 1st ed., 2015.
6. Larry James, *The First Book of Life Skills*, Embassy Books, 1st ed., 2016.
7. Shalini Verma, *Development of Life Skills and Professional Practice*, Sultan Chand (G/L) & Company, 1st ed., 2014.
8. Daniel Goleman, *Emotional Intelligence*, Bantam, 2006.
9. Remesh S., Vishnu R.G., *Life Skills for Engineers*, Ridhima Publications, 1st ed., 2016.
10. Butterfield Jeff, *Soft Skills for Everyone*, Cengage Learning India Pvt Ltd, 1st ed., 2011.
11. *Training in Interpersonal Skills: Tips for Managing People at Work*, Pearson Education, India; 6th ed., 2015.
12. *The Ace of Soft Skills: Attitude, Communication and Etiquette for Success*, Pearson Education, 1st ed., 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
	Module 1	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
	Module 2	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
	Module 3	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
	Module 4	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 ATHANASIOUS 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	P/F	2024

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:

CO 1	Exhibit/show a thorough understanding of the fundamental principles of the design thinking methodology. (Cognitive Knowledge Level: Understand)
CO 2	Utilize diverse techniques effectively to generate creative concepts, adopting innovation and ideation. (Cognitive Knowledge Level: Apply)
CO 3	Demonstrate expertise in ideating prototypes, models, and proof-of-concept iterations. (Cognitive Knowledge Level: Analyse)
CO 4	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

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test (% Marks)	Case Study Presentation (% 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
100	50	50

Continuous Internal Evaluation Pattern

Attendance	10 marks
Continuous Assessment Test	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 and Tamer M. Shahin, *Engineering Design Process*, Course Technology, 2010.
2. Clive L. Dym, Patrick Little and Elizabeth J Orwin, *Engineering Design-A Project based Introduction*, Wiley, 2014.
3. Don Norman, *The Design of Everyday Things*, Basic Books, 2nd ed., 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, 2017.
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*, Harper Collins, 2019.
5. V. N. Mittle & Arvind Mittal, *Basic Electrical Engineering*, McGraw Hill, 2nd ed., 2006.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	24 Hours
	Module 1	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
	Module 2	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
	Module 3	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
	Module 4	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: 4

Reg.No.:

Name:

**MAR ATHANASIOUS 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 marks)

OR

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

OR

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

OR

10. List the different methods in which the prototype of a product can be generated and tested. (7 marks)
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 marks)

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 marks)

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 and Lifestyle Physical fitness, wellness and exercise programmes, First aid and Postures and 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:

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

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1							2	3	2		2
CO 2							3	3	2		2
CO 3						2	3	3	3		2
CO 4							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 and 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, Pawanuktasana, Ardha Chakrasana, Bhujangasana, Shavasana. Obesity: Procedure, Benefits and contraindications for Vajrasana, Hastasana, Trikonasana, Ardha Matsyendrasana. Back pain: Tadasana, Ardha 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 coordinative 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 everyday 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 Ajmer Singh.
2. *Light on Yoga* by B. K. S. Iyengar.
3. *Health and Physical Education*, NCERT (11th and 12th Classes).

Reference Books

1. *Physiological Aspects of Sports Training and Performance* by Jay Hoffman.
2. *Periodization Theory and Methodology of Training* by Tudor O. Bompa and G. Grissmer Haff.
3. *Essential of Strength Training and Conditioning* by Thomas Baechle E. R., Roger W. Earle.
4. *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
	Module 1	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
	Module 2	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 coordinative 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
	Module 3	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
	Module 4	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.

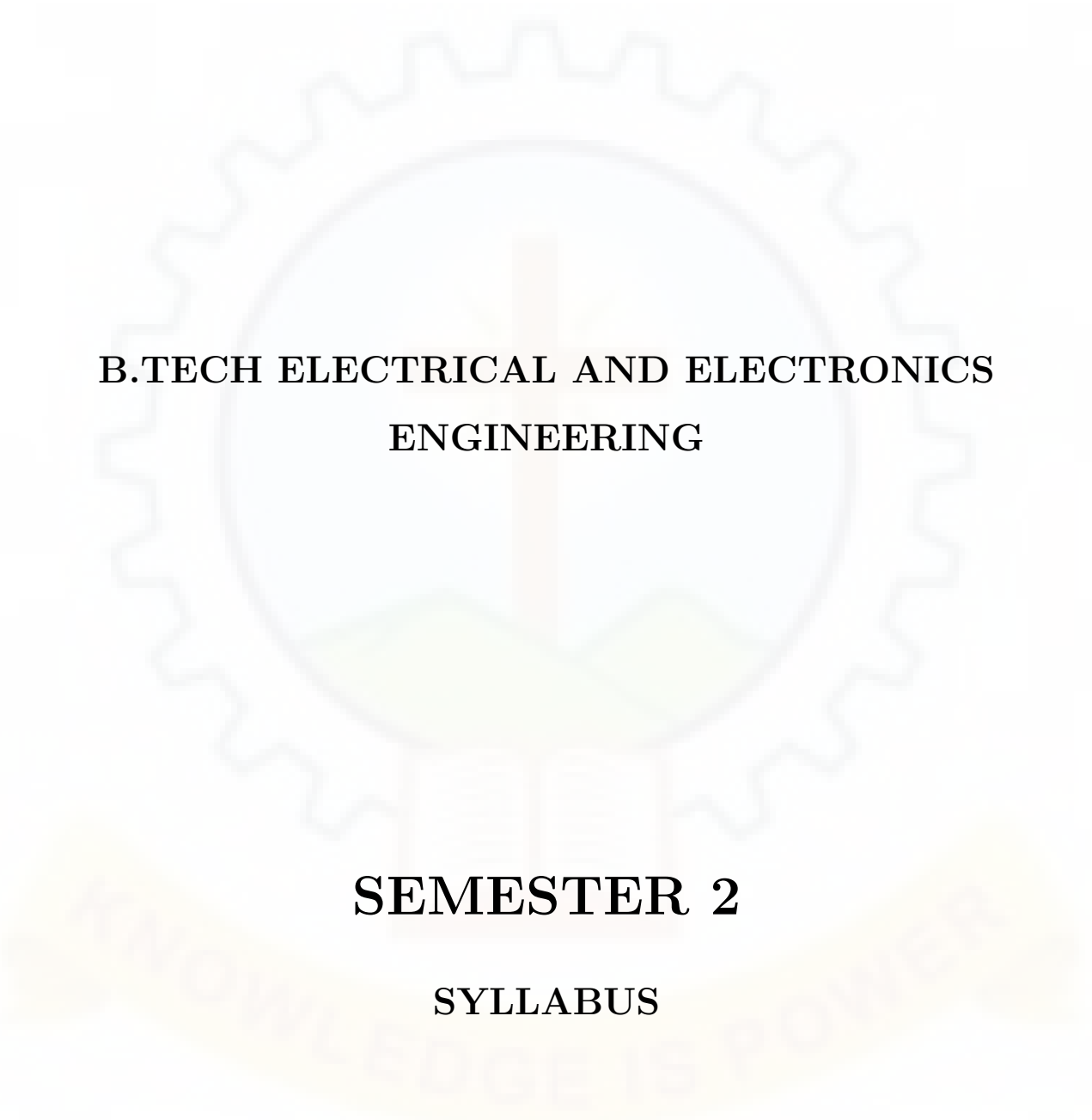
Course Outcome 4 (CO 4)

1. Observe at least 10 students in your class and identify common postural deformities each one of them have. Also identify good postures 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



**B.TECH ELECTRICAL AND ELECTRONICS
ENGINEERING**

SEMESTER 2

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	B24PH1T01A	ENGINEERING PHYSICS(A)	2-1-0-4	3	3
C	B24CY1T01A	ENGINEERING CHEMISTRY(A)	2-1-0-4	3	3
D	B24ES1T05A	BASIC CIVIL AND MECHANICAL ENGINEERING(A)	2-2-0-5	4	4
E	B24EE1T03	ELECTRICAL MEASUREMENTS	2-1-0-4	3	3
F	B24ES1L04A	BASIC CIVIL AND MECHANICAL ENGINEERING WORKSHOP(A)	0-0-2-1	2	1
G	B24EE1L02	ELECTRONIC CIRCUITS LAB I	0-0-3-2	3	2
H	B24PC1L01A	PHYSICS(A) AND ENGINEERING CHEMISTRY LAB(A)	0-0-2-2	2	1
I	B24MC1T03	PROFESSIONAL COMMUNICATION AND ETHICS	2-0-1-4	3	P/F
J	B24MC1L02	IDEA LAB	0-0-3-3	3	P/F
TOTAL				30	21

B24MA1T02	ORDINARY DIFFERENTIAL EQUATIONS AND TRANSFORMS	L	T	P	S	CREDIT	YEAR OF 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. (Cognitive Knowledge Level: Apply)
CO 2	Determine the convergence and divergence of sequences and series using standard convergence tests. (Cognitive Knowledge Level: Apply)
CO 3	Apply Taylor series, Fourier series, and half-range expansions to represent functions. (Cognitive Knowledge Level: Apply)
CO 4	Determine the Fourier transforms of functions and apply them to solve problems arising in engineering. (Cognitive Knowledge Level: Apply)
CO 5	Apply Laplace transforms to model and solve engineering systems governed by ordinary differential equations. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
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 (% 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/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 (9 hours)

Ordinary Differential Equations

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.

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

MODULE 2 (9 hours)

Sequences and Series

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.

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

MODULE 3 (9 hours)

Fourier Series

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.

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

MODULE 4 (9 hours)

Fourier Transforms

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).

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

MODULE 5 (9 hours)

Laplace Transforms

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.

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

Text Books

1. H. Anton, I. Biven, and S. Davis, *Calculus*, Wiley, 10th ed., 2015.
2. Erwin Kreyszig, *Advanced Engineering Mathematics*, John Wiley & Sons, 10th ed., 2016.

Reference Books

1. J. Stewart, *Essential Calculus*, Cengage, 2nd ed., 2017.
2. G. B. Thomas and R. L. Finney, *Calculus and Analytic geometry*, Pearson, Reprint, 9th ed., 2002.
3. Peter O. Neil, *Advanced Engineering Mathematics*, Thomson, 7th ed., 2007.
4. Louis C. Barret, and C. Ray Wylie, *Advanced Engineering Mathematics*, Tata McGraw Hill, 6th ed., 2003.
5. Veerarajan T, *Engineering Mathematics for first year*, Tata McGraw-Hill, 2008.
6. B.S. Grewal, *Higher Engineering Mathematics*, Khanna Publishers, 43 ed., 2015.
7. 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
	Total Hours	45 Hours
1	Module 1: Ordinary Differential Equations	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	Module 2: Sequences and Series	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	Module 3: Fourier series	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	Module 4: Fourier Transforms	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	Module 5: Laplace Transforms	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

CO ASSESSMENT QUESTIONS

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

1. Find the general solution to $2x^2 \frac{d^2y}{dx^2} + x \frac{dy}{dx} - 3y = 0$ given that $y_1(x) = \frac{1}{x}$ is a solution.
2. Solve the initial value problem $x^2y'' - 3xy' + 4y = 0$ 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 Laplace Transform of (i) $e^{-t}\sin^2 t$ (ii) $\delta(t-a)$
3. Solve the differential equation $y'' + 4y = f(t)$, $y(0) = 1$, $y'(0) = 0$ 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 marks)
 (b) By the method of variation of parameters solve $y'' + 4y = \tan 2x$. (7 marks)

OR

12. (a) By the method of undetermined coefficients solve $y'' + 2y' + 4y = 3e^{-x}$. (7 marks)
 (b) Solve $x^2y'' + xy' + 9y = 0, y(1) = 0, y'(1) = 2.5$. (7 marks)
13. (a) Test the convergence of (i) $\sum_{k=1}^{\infty} \frac{3k^3 - 2k^2 + 4}{k^7 - k^3 + 2}$ (ii) $\sum_{k=1}^{\infty} \frac{k^k}{k!}$. (7 marks)
 (b) Check the convergence of the series $1 + \frac{1.3}{3!} + \frac{1.3.5}{5!} + \frac{1.3.5.7}{7!} + \dots$ (7 marks)

OR

14. (a) Determine whether the series $\sum_{k=1}^{\infty} \frac{1}{\sqrt{k+1}}$ is absolutely convergent or conditionally convergent. (7 marks)
 (b) Test the convergence of (i) $\sum_{k=1}^{\infty} \frac{k!}{3!(k-1)!3^k}$ (ii) $\sum_{k=1}^{\infty} \left(\frac{4k-5}{2k+1}\right)^k$ (7 marks)
15. (a) Expand into a Fourier series, $f(x) = e^{-x}, 0 < x < 2\pi$. (7 marks)
 (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 marks)

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 marks)
 (b) Find the half range cosine series for $f(x) = (x-1)^2$ in $0 \leq x \leq 1$. (7 marks)
17. (a) Find the Fourier transform of $f(x) = \begin{cases} 1 & \text{if } |x| < 1 \\ 0 & \text{otherwise} \end{cases}$ (7 marks)
 (b) Find the Fourier sine integral of $f(x) = \begin{cases} \sin x & , 0 \leq x \leq \pi \\ 0 & , x > \pi \end{cases}$ (7 marks)

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 marks)
 (b) Find the Fourier sine transform of $f(x) = \begin{cases} k & , 0 < x < a \\ 0 & , x > a \end{cases}$ (7 marks)
19. (a) Find the Laplace transform of (i) $t \sin 2t$ (ii) $e^{-t} \sin 3t \cos 2t$ (7 marks)
 (b) Using convolution theorem find $L^{-1} \left\{ \frac{1}{s(s^2+4)} \right\}$ (7 marks)

OR

20. (a) Find $L^{-1} \left\{ \frac{4s+5}{(s+2)(s-1)^2} \right\}$. (7 marks)
 (b) Use Laplace transform to solve $y'' + 2y' + 2y = 0, y(0) = y'(0) = 1$. (7 marks)

B24PH1T01A	ENGINEERING PHYSICS(A)	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

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. (Cognitive Knowledge Level: Apply)
CO 2	Formulate and solve the time-independent Schrödinger equation for a particle in a one-dimensional box, interpreting wave functions and energy eigenvalues. (Cognitive Knowledge Level: Apply)
CO 3	Analyze electrical conduction in solids using Fermi-Dirac statistics and evaluate the charge carrier concentrations in intrinsic semiconductors. (Cognitive Knowledge Level: Apply)
CO 4	Evaluate carrier concentrations in extrinsic semiconductors and interpret the variation of the Fermi level with temperature and doping concentration. (Cognitive Knowledge Level: Apply)
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. (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	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 (% Marks)
	Test 1 (% Marks)	Test 2 (% 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 and 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, and 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, 4th ed., 2012.

Reference Books

1. Arthur Beiser, *Concepts of Modern Physics*, Tata McGraw Hill Publications, 6th ed., 2003.
2. D. K. Bhattacharya, and Poonam Tandon, *Engineering Physics*, Oxford University Press, 2015.
3. Md. N. Khan and S. Panigrahi *Principles of Engineering Physics 1 & 2*, Cambridge University Press, 2016.
4. 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
	Module 1: Laser and Fibre Optics	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
	Module 2: Quantum Mechanics	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
	Module 3: Semiconductor Physics I	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
	Module 4: Semiconductor Physics II	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
	Module 5: Semiconductor Devices	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.

11. (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 marks)
- (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 marks)

OR

12. (a) Outline the construction and working of Ruby laser. (10 marks)
- (b) Calculate the N.A. of an optic fiber having core index of 1.54 and cladding index of 1.5 (4 marks)
13. (a) Derive time dependent Schrodinger equation. (10 marks)
- (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 marks)

OR

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

OR

16. (a) Derive the equation for the intrinsic carrier concentration. (10 marks)
- (b) Let $T=300\text{ K}$. Determine the probability that an energy level $3kT$ above the Fermi energy is occupied by an electron. (4 marks)
17. (a) Derive the fundamental relationship $n_0 p_0 = n_i^2$. (10 marks)
- (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 marks)

OR

18. (a) Derive the equations for n_0 and p_0 in terms of impurity doping concentrations. (10 marks)
- (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 marks)

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

OR

20. (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 marks)
- (b) Briefly describe the working of a PIN junction photodiode and explain its advantage over a PN junction photodiode. (4 marks)

B24CY1T01A	ENGINEERING CHEMISTRY(A)	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

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:

CO 1	Develop a comprehensive understanding of nanoscale materials, including their synthesis, fundamental properties and diverse applications. (Cognitive Knowledge Level: Apply)
CO 2	Understand the principles and applications of various spectroscopic techniques and microscopic techniques such as SEM. (Cognitive Knowledge Level: Apply)
CO 3	Demonstrate an inclusive understanding of the principles of electrochemistry and corrosion. Also gain knowledge about various corrosion control methods. (Cognitive Knowledge Level: Apply)
CO 4	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)
CO 5	Apply the knowledge of conducting polymers and advanced materials in engineering. (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	1	1	1			1		1
CO 2	2	2		2	1				1		1
CO 3	2	1			1				1		1
CO 4	2	2	1		1				1		1
CO 5	2	1	1	1	1	1			1		1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% 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, 17th ed., 2015.
2. Shashi Chawla, *A Text Book of Engineering Chemistry*, Dhanpat Rai and Co.(P) Limited, 2017.
3. Muhammed Arif, Annette Fernandez, and 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, and Rino Laly Jose, *Text Book of Engineering Chemistry*, S. Chand and Company Pvt. Ltd., 2019.
7. B. L. Tembe, Kamaluddin, and M. S. Krishnan, *Engineering Chemistry* (NPTEL Web Book), 2018.

Reference Books

1. T. Pradeep, *NANO: The Essentials: Understanding Nanoscience and Nanotechnology*, McGraw-Hill, 2008.
2. B. Rogers, J. Adams, and S. Pennathur, *Nanotechnology: Understanding Small Systems*, CRC Press, 2014.
3. Donald L. Pavia, *Introduction to Spectroscopy*, Cengage Learning India Pvt. Ltd., 2015.
4. J. Goldstein, *Scanning Electron Microscopy and Microanalysis*, Springer, 2012.
5. H. H. Willard, L. L. Merritt, *Instrumental Methods of Analysis*, CBS Publishers, 7th ed., 2005.
6. Samuel Glasstone, *An Introduction to Electrochemistry*, East-West Press Pvt. Ltd., 2006.

7. Pietro Pedferri, *Corrosion Science and Engineering*, Springer Link, 2018.
8. B. Sunden, *Hydrogen, Batteries and Fuel Cells*, Elsevier Inc., 2019.
9. B. Sorensen and G. Spazzafumo, *Hydrogen and Fuel Cells - Emerging Technologies and Applications*, Elsevier Ltd., 2018.
10. Raymond B. Seymour, and Charles E. Carraher, *Polymer Chemistry: An Introduction*, Marcel Dekker Inc; 4th ed., Revised, 1996.
11. J. Janata, *Principles of Chemical Sensors*, Springer, New York, NY, 2009.
12. F-G. Banica, *Chemical Sensors and Biosensors: Fundamentals and Applications*, John Wiley and Sons, 2012.
13. M. Schwartz, *Smart Materials*, CRC Press, 2008.
14. Y. Zhao, and T. Ikeda, *Smart Light-Responsive Materials*, Wiley, 2009.
15. V. Khutoryanskiy, and T. Georgiou, *Temperature-Responsive Polymers: Chemistry, Properties and Applications*, Wiley, 2018.
16. P. W. Atkins, *Physical Chemistry*, Oxford University Press, 10th ed., 2014.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Fundamentals of Nanomaterials	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
	Module 2: Spectroscopic and Microscopic Techniques	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
	Module 3: Introduction to Electrochemistry and Corrosion Science	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
	Module 4: Energy Storage and Harvesting Technologies	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
	Module 5: Advanced Materials and Devices for Engineering Applications	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**

SECOND SEMESTER B.TECH DEGREE EXAMINATION, JUNE 2025

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 marks)

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

OR

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

OR

14. (a) Illustrate the vibrational modes of CO_2 and H_2O . Justify its IR activity. (9 marks)
(b) Explain the various energy levels associated with a molecule. (5 marks)
15. (a) How electroless plating of copper is carried out? Give the procedure and reactions. (8 marks)
(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°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 marks)

OR

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

OR

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

OR

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

B24ES1T05A	BASIC CIVIL AND MECHANICAL ENGINEERING(A)	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	2	0	5	4	2024

Preamble

The objective of this course is to provide insight and inculcate the essentials of the Civil and Mechanical Engineering discipline to the students of Electrical Engineering and to provide the students with an illustration of the significance of the Civil and Mechanical Engineering Profession in satisfying the societal needs.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand Civil Engineering history, disciplines, surveying, and apply sustainable building practices in real-world scenarios. (Cognitive Knowledge Level: Apply)
CO 2	Comprehend the Materials, energy systems, water management, and environment for green buildings. (Cognitive Knowledge Level: Understand)
CO 3	Solve engineering problems by analyzing forces, moments, and equilibrium in coplanar systems using free-body diagrams. (Cognitive Knowledge Level: Apply)
CO 4	Illustrate the workings of IC engines and hydraulic machines. (Cognitive Knowledge Level: Apply)
CO 5	Explain the basic principle of power transmission elements and material handling devices. (Cognitive Knowledge Level: Analyse)
CO 6	Describe the fundamentals of power plant engineering and air conditioning systems. (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	2		1	3	1				2
CO 2	2	1	2		1	3	2				2
CO 3	3	3		1							2
CO 4	3	2				1					
CO 5	3	2	1								
CO 6	3	2				2	1				

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	20	20	15
Understand	40	40	35
Apply	40	40	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/Quiz/Course Project	10 marks
Self Study	5 marks

End Semester Examination Pattern

There will be two parts for the end semester examination: Part I – Basic Civil Engineering and Part II – Basic Mechanical Engineering. Part I and Part II carry 50 marks each. Part I contains 2 parts - Part A and Part B. Part A contains 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 a maximum 2 sub-divisions. The pattern for the end semester examination for Part II is the same as that of Part I. **The student should answer both Part I and Part 2 in separate answer booklets.**

SYLLABUS

MODULE 1 (7 hours)

Introduction to Civil Engineering

Relevance of Civil Engineering in the overall infrastructural development of the country. Brief introduction to major disciplines of Civil Engineering.

Construction Materials: Conventional construction materials - bricks, stones, cement, sand, timber and steel. Cement concrete: Constituent materials and properties. Other construction materials: Glass, Ceramics, Plastics, Composite materials, Thermal and acoustic insulating materials, Decorative panels, Water proofing materials.

Surveying: Basic Principles of surveying, instruments, methods, and measurements (brief discussion only).

Environment: Water Supply and Sanitary Systems, Urban Air Pollution Management, Solid Waste Management, Urban Flood Control (brief discussion only).

Earth Pitting Mechanisms: Increase in ground resistance and its consequences, Impact on equipment safety and reliability.

MODULE 2 (8 hours)

Types of Buildings: Components of a residential building and their functions.

Types of Structures: Load-bearing wall structures and Framed structures.

Building Area: Plinth area, built-up area, floor area, carpet area, and floor area ratio for a building as per KMBR.

Building Rules and Regulations: Relevance of NBC, KBR & CRZ norms (brief discussion only).

Green Buildings: Materials, energy systems, water management and environment for green buildings.

MODULE 3 (9 hours)

Introduction to Statics

Concept of Idealization, System of Forces, Principles of Superposition and Transmissibility, Resolution and Composition of Forces, Law of Parallelogram of Forces. Resultant of Concurrent and Non-concurrent Coplanar Force Systems. Moment of Forces, Couple, Varignon's Theorem, Free Body Diagram. Equations of Equilibrium, Equilibrium of Concurrent and Non-concurrent Coplanar Force Systems.

MODULE 4 (8 hours)

Internal Combustion Engines

Introduction, Terminologies, IC engine parts, Working of SI and CI engine, Two stroke and Four stroke engine, Fuel, Cooling and Lubrication systems, CRDI and MPFI engines. Concept of hybrid engines.

Hydraulic Machines

Classification of hydraulic turbines, Working of Pelton, Francis, and Kaplan turbines (Descriptions with figures only). Pumps: Classification and working of Centrifugal and Reciprocating pumps.

MODULE 5 (8 hours)

Power Transmission Elements

Classification and applications of mechanical drives, Velocity ratio of belt drive, Length of belt, Slip in belt, Power transmitted, simple problems. Gear drive: Types, Gear Ratio, Simple, compound, and epicyclic gear trains (simple descriptions only).

Material Handling

Objective, principle, and selection of material handling equipment, Types of conveyors, parts, and working of belt conveyors, screw conveyors and pneumatic conveyor- Hoisting machine, Elevators, Winches, and Cranes – Types – Concrete Pumps -Types, Working (Descriptions only).

MODULE 6 (8 hours)

Power Plant Engineering

Hydel power plants: Layout, classifications, and study of various components. Steam power plant: Layout, steam generators, study of various components. Gas turbine power plant and combined power plants, Layout. New generation power producing systems.

Air Conditioning

Units of Refrigeration, Refrigeration effect, Psychrometric properties, Psychrometric chart, Comfort conditions, window, split and centralized air condition system, Summer and Winter air-conditioning, Inverter Technology in Air conditioners, Solar Air conditioners.

Text Books

1. S. K. Duggal, *Building Materials*, New Age International Publishers, 4th ed., 2021.
2. B. C. Punmia, Ashok Kumar Jain, and Arun Kumar Jain, *Building Construction*, Laxmi Publications, 11th ed., 2016.
3. S. Timoshenko and D.H. Young, *Engineering Mechanics*, McGraw Hill Education, 5th ed., 2017.
4. I. B. Prasad, *Engineering Mechanics: Statics and Dynamics*, Khanna Publishers, 3rd ed., 2017.
5. J. Benjamin, *Basic Mechanical Engineering*, Pentex Books, 9th ed., 2018
6. P. Balachandran, *Basic Mechanical Engineering*, Owl Books, 1st ed., 2015.

Reference Books

1. M. S. Shetty and A. K. Jain, *Concrete Technology: Theory and Practice*, S. Chand & Company Pvt. Ltd., 9th ed., 2021.
2. R. Subramanian, *Surveying and Levelling*, Oxford University Press, 2nd ed., 2020.
3. Bindu B. Menon and G. Shivanand Rao, *Building Planning and Drawing*, Charotar Publishing House Pvt. Ltd., 1st ed., 2014.
4. S. K. Sharma, *Building Construction*, S. Chand & Company Pvt. Ltd., 3rd ed., 2016.
5. A. K. Tayal, *Engineering Mechanics*, Umesh Publications, 14th ed., 2019.
6. S. S. Bhavikatti, *Engineering Mechanics*, New Age International Publishers, 5th ed., 2018.
7. M. Clifford, K. Simmons, *An Introduction to Mechanical Engineering, Part I*, CRC Press.
8. K. P. Roy, S. K. H. Choudhary, N. Roy, *Elements of Mechanical Engineering*. Media Promoters & Publishers Pvt. Ltd., 7th ed., 2012.
9. S. Ray, *Introduction to material handling*, New Age International, 1st ed., 2008.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	48 Hours
1	Module 1	7
1.1	Introduction to Civil Engineering: Relevance of Civil Engineering in the overall infrastructural development of the country. Brief introduction to major disciplines of Civil Engineering	1
1.2	Construction materials: Conventional construction materials - bricks, stones, cement, sand, timber and steel. Cement concrete: Constituent materials and properties. Other construction materials: Glass, Ceramics, Plastics, Composite materials, Thermal and acoustic insulating materials, Decorative panels, Water proofing materials	2
1.3	Surveying: Basic Principles of surveying, instruments, methods, and measurements (brief discussion only)	1
1.4	Environment: Water Supply and Sanitary Systems, Urban Air Pollution Management, Solid Waste Management, Urban Flood Control (brief discussion only)	2
1.5	Earth Pitting Mechanisms: Increase in ground resistance and its consequences, Impact on equipment safety and reliability	1
2	Module 2	8
2.1	Types of buildings: components of a residential building and their functions	1
2.2	Types of structures: Load-bearing wall structures and Framed structures	1
2.3	Building area: Plinth area, built-up area, floor area, carpet area, and floor area ratio for a building as per KMBR	2
2.4	Building rules and regulations: Relevance of NBC, KBR & CRZ norms (brief discussion only)	2
2.5	Green buildings: Materials, energy systems, water management and environment for green buildings	2
3	Module 3	9
3.1	Concept of Idealization, System of Forces, Principles of Superposition and Transmissibility	1
3.2	Resolution and Composition of Forces	1
3.3	Law of Parallelogram of Forces	1
3.4	Resultant of Concurrent and Non-concurrent Coplanar Force Systems	1
3.5	Moment of Forces, Couple	1
3.6	Varignon's Theorem, Free Body Diagram	2
3.7	Equations of Equilibrium, Equilibrium of Concurrent and Non-concurrent Coplanar Force Systems	2

4	Module 4	8
4.1	Introduction, Terminologies, IC engine parts	1
4.2	Working of four-stroke SI and CI engine, Working of two-stroke SI and CI engine	2
4.3	Fuel, Cooling and Lubrication systems, CRDI and MPFI engines, Concept of hybrid engines	2
4.4	Hydraulic Machines: Classification of hydraulic turbines, Working of Pelton, Francis, and Kaplan turbines (Descriptions with figures only)	2
4.5	Pumps: Classification and working of Centrifugal and Reciprocating pumps	1
5	Module 5	8
5.1	Power Transmission Elements: Classification and applications of mechanical drives, Velocity ratio of belt drive, Length of belt, Slip in belt, Power transmitted, simple problems	2
5.2	Gear drive: Types, Gear Ratio, Simple, compound, and epicyclic gear trains (simple descriptions only)	2
5.3	Material Handling: Objective, principle, and selection of material handling equipment, Types of conveyors, parts, and working of belt conveyors, screw conveyors, and pneumatic conveyors	2
5.4	Hoisting machine, Elevators, Winches, and Cranes – Types – Concrete Pumps -Types, Working (Descriptions only)	2
6	Module 6	8
6.1	Power Plant Engineering: Hydel power plants: Layout, classifications and study of various components. Steam power plant: Layout, steam generators, study of various components	2
6.2	Gas turbine power plant and combined power plants, Layout. New generation power producing systems	2
6.3	Air Conditioning: Units of Refrigeration, Refrigeration effect, Psychrometric properties, Psychrometric chart, Comfort conditions, window, split and centralized air condition system	2
6.4	Summer and Winter air-conditioning, Inverter Technology in Air conditioners, Solar Air conditioners	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Define the role of a civil engineer in society.
2. Address complex challenges in the built environment.

3. How do civil engineers contribute to the development of environmentally conscious infrastructure?

Course Outcome 2 (CO 2)

1. Examine the role of materials in green building construction
2. Evaluate the integration of energy systems in green buildings.
3. How do green building practices address water conservation, reuse, and efficient management of water resources?

Course Outcome 3 (CO 3)

1. Discuss the fundamental principles of forces and moments in static equilibrium.
2. How do engineers apply the principles of statics to solve physical problems?
3. Explore the applications of forces and moments in mechanical systems

Course Outcome 4 (CO 4)

1. Describe the working of a four-stroke diesel engine.
2. Why two stroke engines are less efficient than our stroke engine?
3. How hydraulic turbines are classified?

Course Outcome 5 (CO 5)

1. Derive an expression to determine the length of an open belt drive
2. Solve problem based on velocity ratio of a gear drive
3. What are the important components of a conveyer belt drive? Explain with figure.

Course Outcome 6 (CO 6)

1. With the aid of a neat sketch, explain the working of a thermal power plant.
2. List the advantage of a combined power plant over the steam power plant.
3. How the operation of a summer air conditioner differs from a winter air conditioner?

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: B24ES1T05A

Course Name: BASIC CIVIL AND MECHANICAL ENGINEERING(A)

Max. Marks: 100

Duration: 3 hours

Answer both PART I and PART II in separate answer booklets.

PART I: BASIC CIVIL ENGINEERING

PART A

Answer all questions. Each question carries 4 marks.

1. How does Civil Engineering contribute to the comprehensive development of a country's infrastructure?
2. How does the increase in ground resistance due to earth pitting mechanisms?
3. Elaborate on how the Floor Area Ratio (FAR) is determined for a building.
4. Compare load-bearing masonry structures and framed structures.
5. Demonstrate the application of parallelogram law of forces in understanding force vectors.

PART B

Answer any one question from each module. Each question carries 10 marks.

6. Provide a concise overview of the basic principles, instruments, methods, and measurements involved in surveying.

(10 marks)

OR

7. How do water supply and sanitary systems, urban air pollution management, solid waste management, and urban flood control collectively contribute to environmental sustainability in urban areas? (10 marks)
8. How do green buildings incorporate sustainable practices in terms of materials, energy systems, water management, and overall environmental considerations? (10 marks)

OR

9. Explain the essential components of a residential building and elaborate on their functions within the functionality of the structure. (10 marks)
10. What are the laws to add two forces and several concurrent, coplanar forces? Explain in detail. (10 marks)

OR

11. Explain various force systems with neat sketches. (10 marks)

PART II: BASIC MECHANICAL ENGINEERING

PART A

Answer all questions. Each question carries 4 marks.

1. With the neat block diagram, explain the fuel system of a CI engine.
2. Illustrate the working of an epicyclic gear train.
3. Explain the principles of material handling.
4. Explain cooling and dehumidification processes.
5. Define: Specific humidity, relative humidity and dew point temperature.

PART B

Answer any one question from each module. Each question carries 10 marks.

6. Explain the working of a 4-stroke CI engine with the help of a neat diagram. (10 marks)

OR

7. With the aid of a neat sketch, describe the working of a Francis turbine. (10 marks)
8. (a) Discuss the factors to be considered while selecting a material handling equipment. (4 marks)
- (b) What are the different types of belt conveyers? Explain its important parts of a flat belt conveyer system. (6 marks)

OR

9. Two flat belt pulleys having a centre-to-centre distance of 137 cm have drive diameter of 72 cm and 36 cm. (10 marks)
 - i. Determine the length of the belt if both pulleys will rotate in same direction.
 - ii. Determine the angle of contact on the small and big pulley.
 - iii. Calculate the belt length if the belt will be cross-connected to make the pulleys rotate in opposite directions.
 - iv. Determine the angle of contact for opposite direction.
10. Explain the general layout of a hydroelectric power plant. (10 marks)

OR

11. (a) How summer air conditioners differ from winter air conditioners. (5 marks)
- (b) Explain the working of summer air conditioner with the aid of a neat sketch. (5 marks)

B24EE1T03	ELECTRICAL MEASUREMENTS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4		

Preamble

The course aims to build a solid foundation that empowers to analyze and comprehend the measurement of the circuit parameters and magnetic quantities. It provides the basic knowledge about the construction, principles, and applications of analog and digital measuring instruments. Upon successful completion of the course students will be thorough with various measuring techniques that are required for an electrical engineer.

Prerequisites

Nil

Course Outcomes

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

CO 1	Identify and analyze the factors affecting the performance of the measuring system and select appropriate instruments for the measurement of voltage and current in DC measurements. (Cognitive knowledge level: Apply)
CO 2	Understand the measurement of power and energy in poly-phase systems. (Cognitive knowledge level: Understand)
CO 3	Design electrical bridges to measure resistance, inductance, capacitance, and frequency. (Cognitive knowledge level: Apply)
CO 4	Understand the principle of operation of CRO and apply the methods to measure magnetic and electric parameters. (Cognitive knowledge level: Apply)
CO 5	Understand the importance and working of digital instruments. (Cognitive knowledge level: Understand)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	30	40	30
Understand	40	40	50
Apply	30	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)

Measurement Systems

Measurement standards, static and dynamic characteristics of instruments, errors in instruments, need for calibration, classification of instruments, secondary instruments, indicating, integrating and recording, operating forces, essentials of indicating instruments - deflecting, damping, controlling torques - Numerical problems.

Measurement of Current and Voltage

Moving coil and moving iron instrument- constructional details and operation, ammeter shunts, voltmeter multipliers - Numerical problems.

MODULE 2 (10 hours)

Measurement of Power and Energy

Dynamometer type wattmeter - construction and working, low power factor wattmeter, power in polyphase systems, measurement of power in three phases balanced and unbalanced systems, measurement of reactive volt-amperes, Induction type single phase energy meters- construction, theory and operation, errors, compensation and adjustments, direct and phantom loading.

Instrument Transformers

Principle of working, ratio and phase angle errors, extension of range.

MODULE 3 (6 hours)

Measurement of Resistance, Inductance, and Capacitance

Ammeter-voltmeter method, Kelvin's double bridge, Wheatstone bridge, loss of charge method, measurement of earth resistance, Maxwell inductance bridge, Schering bridge, Wien bridge - Numerical problems. General principle of slide wire potentiometer and Crompton potentiometer.

MODULE 4 (6 hours)

Magnetic Measurements

Measurement of flux/flux density, determination of BH curve and hysteresis loop - step-by-step method, method of reversals, permeability measurement, ballistic galvanometer and flux meter - construction and principle of operation.

Oscilloscopes

Principle of operation of general purpose CRO - basics of vertical and horizontal deflection system, XY mode - Lissajous Pattern.

MODULE 5 (7 hours)

Digital Meters

Advantages and disadvantages of digital instruments, resolution, accuracy, and error in digital instruments. Digital voltmeters and frequency meters using electronic counters, digital multimeters, clamp-on meters, Time of Day meter (TOD), smart metering (description only), and Phasor Measurement Unit (PMU) (description only). Power quality analyzer, digital insulation resistance tester, proximity sensor, introduction to virtual instrumentation systems - Simulation software LabVIEW (description only).

Text Books

1. A. K. Sawhney, *A course in Electrical and Electronic Measurements and Instrumentation*, Dhanpat Rai, 19th ed., 2015.
2. J. B. Gupta, *A course in Electrical & Electronic Measurement and Instrumentation*, S.K Kataria & Sons, 14th ed., 2014.
3. H. S. Kalsi, *Electronic Instrumentation*, Tata McGraw Hill, 3rd ed., 2017.
4. E.O Doebelin and D.N Manik, *Doebelin's Measurements Systems: Application and Design*, McGraw Hill Education, 6th ed., 2017.

Reference Books

1. E. W. Golding, *Electrical Measurements & Measuring Instruments*, Pitman 3rd ed., 2011
2. William D. Cooper and Albert D. Helfrick, *Modern Electronic Instrumentation and Measurement Techniques*, Prentice Hall India Learning 1st ed., 1992.
3. Melville B. Stout, *Basic Electrical Measurements*, Prentice Hall Inc., 2nd ed., 1961.
4. David A. Bell, *Electronic Instrumentation and Measurements*, Oxford University Press, 3rd ed. 2013.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1	7
1.1	Measurement standards, static and dynamic characteristics of instruments	1
1.2	Errors in instruments, need for calibration	1
1.3	Classification of instruments, secondary instruments, indicating, integrating, and recording	1
1.4	operating forces, essentials of indicating instruments - deflecting, damping, controlling torques - Numerical problems	1
1.5	Moving coil instrument- constructional details, principle of operation, and numerical Problems	1
1.6	Moving iron instrument- constructional details, the principle of operation, and numerical Problems	1
1.7	Ammeter shunts, voltmeter multipliers - Numerical problems	1
	Module 2	10
2.1	Dynamometer-type wattmeter - construction and working.	1
2.2	Low power factor wattmeter, power in polyphase systems	1
2.3	Measurement of power in three phases, balanced and unbalanced systems, measurement of reactive volt-amperes	2
2.4	Induction type single-phase energy meters- construction, theory and operation, errors, compensation, and adjustments	2
2.5	Direct and Phantom Loading	1
2.6	Single phase transformer- principle and working	1
2.7	Instrument transformers – current and potential transformers- principle of working -ratio and phase angle errors. Extension of range	2
	Module 3	6
3.1	Measurement of resistance- Ammeter voltmeter method, Kelvin's double bridge, Wheatstone bridge	1
3.2	loss of charge method, measurement of earth resistance	1
3.3	Measurement of inductance and capacitance: Maxwell inductance bridge, Schering bridge, Numerical problems	1
3.4	Wien bridge - Numerical problems	1
3.5	General principle of slide wire potentiometer and Crompton potentiometer	2
	Module 4	6
4.1	Measurement of flux/flux density, determination of BH curve and hysteresis loop - step-by-step method, method of reversals	2

4.2	Ballistic galvanometer -construction and principle of operation	1
4.3	Flux meter - construction and the principle of operation	3
4.4	Oscilloscopes - Principle of operation of general purpose CRO - basics of vertical and horizontal deflection system, XY mode - Lissajous Pattern	2
	Module 5	7
5.1	Digital Meters: Advantages and disadvantages of digital instruments, resolution, accuracy, and error in digital instruments	1
5.2	Digital voltmeters and frequency meters using electronic counters	1
5.3	Digital multimeters, clamp-on meters, Time of Day meter (TOD), smart metering (description only), and Phasor Measurement Unit (PMU) (description only)	2
5.4	Power quality analyzer, digital insulation resistance tester, proximity sensor	2
5.5	Introduction to Virtual Instrumentation Systems - Simulation software LabVIEW (description only)	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain classification and characteristics of measuring systems.
2. Explain the construction and working of indicating Instruments.
3. Problems related to indicating Instruments.

Course Outcome 2 (CO 2)

1. Describe the principle of operation and construction of energy meters.
2. Describe the principle of operation and construction of the wattmeter.
3. Illustrate the principle and working of Instrument Transformers.

Course Outcome 3 (CO 3)

1. Explain the operation of basic AC/DC bridges.
2. Problems related to the measurement of inductance, capacitance, and frequency.

3. Explain the principle of operation of DC potentiometers.

Course Outcome 4 (CO 4)

1. Explain the principle of operation of the fluxmeter and ballistic galvanometer.
2. Describe the procedure for plotting the BH curve and Hysteresis loop of a magnetic specimen.
3. Block diagram and working principle of CRO.

Course Outcome 5 (CO 5)

1. Explain the Basics of Digital Instruments.
2. Block diagram of DMM, PMU, and TOD.
3. Illustrate the principle of the Power Quality Analyzer, Proximity Sensor, and Digital Insulation Resistance Tester.

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: : B24EE1T03

Course Name: : ELECTRICAL MEASUREMENTS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define the following terms in measurement: i) accuracy, ii) resolution, and iii) precision.
2. The weight of 5 kg is used as the control weight in a gravity-controlled instrument. Find its distance from the spindle if the deflecting torque for a deflection of 600 is 1.13×10^{-3} .
3. With a neat circuit diagram, show how power can be measured in a 3-phase circuit using two-watt meters in unbalanced load conditions.
4. Explain the working principle of a potential transformer with the help of neat diagrams.
5. Explain how insulation resistance can be measured using the loss of charge method.
6. With neat diagrams, outline the principle of slide wire potentiometer.
7. Show how a Ballistic Galvanometer can be used to determine the flux density in a magnetic specimen.
8. Using the diagram, label the parts of Cathode Ray Tube.
9. Explain the working of a Phasor Measurement Unit (PMU).
10. Illustrate the principle of the Power Quality Analyzer.

PART B

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

11. (a) What are the different torques needed for the proper operation of an indicating instrument? (6 marks)
- (b) Explain the construction and principle of operation of a PMMC instrument in a neat diagram. Derive the expression for deflection. (8 marks)

OR

12. (a) Explain three mechanisms for producing damping torque in electrical measuring instruments with neat diagrams. (7 marks)
- (b) Demonstrate how the range of the instrument can be extended in PMMC ammeter and voltmeter. (7 marks)
13. (a) Illustrate with a neat diagram the construction and working of an electrodynamic wattmeter. (8 marks)
- (b) Develop the expression for the torque of a single-phase induction-type energy meter. (6 marks)

OR

14. (a) Demonstrate how the expression for ratio and phase angle error in a current transformer can be derived with the help of a phasor diagram (10 marks)
- (b) Explain phantom loading and its advantages. (4 marks)
15. (a) With necessary diagram, demonstrate how the Kelvin's double bridge can be used for the measurement of low resistances. (6 marks)
- (b) Explain how unknown self-inductance is measured using Maxwell's Inductance bridge with a neat circuit diagram. Derive the expression for unknown self-inductance. Draw the phasor diagram. (8 marks)

OR

16. (a) With necessary diagram and phasor, explain how unknown capacitance is measured using the Schering Bridge. (8 marks)
- (b) The arm of a four-arm bridge ABCD supplied with a sinusoidal voltage has the following values. Arm AB a resistance of $250\ \Omega$ in parallel with a capacitance of $2\ \mu\text{F}$, Arm BC $425\ \Omega$, Arm CD $999\ \Omega$, Arm DA a resistance R_2 in series with a $2.5\ \mu\text{F}$ capacitance. Find the value of R_2 and find the frequency at which the bridge will balance. (6 marks)
17. (a) Explain the measurement of flux in a ring specimen using Flux meter (8 marks)

- (b) What are Lissajous patterns? How are they used for the measurement of frequency and phase angle?

(6 marks)

OR

18. (a) Define the function of each block of a Cathode Ray Oscilloscope using the necessary diagrams.

(10 marks)

- (b) Illustrate with figures the step by step method used for the determination of BH curve of a magnetic material

(4 marks)

19. (a) With neat figures, explain the working principle of frequency meters using electronic counters.

- (b) Show how the rotational speed is measured using Proximity sensors. (6 marks)

OR

20. (a) Explain the basic principle and working of the Digital Insulation Resistance Tester.

(6 marks)

- (b) Summarize the working of (i) Digital Multi Meter (ii) Clamp-on meter (8 marks)

B24ES1L04A	BASIC CIVIL AND MECHANICAL ENGINEERING WORK- SHOP(A)	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	2	1	1	2024

Preamble

This course equips students with practical knowledge in both Civil and Mechanical Engineering, linking theoretical studies to real-world applications and problem-solving. It provides hands-on training in essential tools, materials, and processes, preparing students to manage and execute engineering projects in a collaborative learning environment.

Prerequisite

Nil

Course Outcomes

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

CO 1	Identify and choose key plumbing components and building materials for real-world scenarios. (Cognitive Knowledge Level: Apply)
CO 2	Apply the principles of setting out in construction by successfully setting out a single-room building according to a given building plan, utilizing tape for accurate measurements. (Cognitive Knowledge Level: Apply)
CO 3	Apply the triangle law of forces to solve practical engineering problems involving the equilibrium of forces. (Cognitive Knowledge Level: Apply)
CO 4	Master carpentry joints and tools, smithy forging techniques, and foundry molding and casting processes. (Cognitive Knowledge Level: Apply)
CO 5	Gain proficiency in fitting, welding, conventional machining, and advanced methods like CNC machining and 3D printing. (Cognitive Knowledge Level: Apply)
CO 6	Understand the operation and application of centrifugal, self-priming, and reciprocating pumps, as well as Pelton, Francis, and Kaplan turbines. (Cognitive Knowledge Level: Analyse)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	2	2				2		3	1		2
CO 2	3	3	2		2	1		3	1		3
CO 3	3	3	2		2	1		3	1		3
CO 4	3	2	1		2						
CO 5	3	2	2		3						
CO 6	3	2	1			2	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 college)	30 marks

End Semester Examination Pattern

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

SYLLABUS

LIST OF EXPERIMENTS

PART I

CIVIL WORKSHOP

(Any 05 experiments are mandatory)

1	Plumbing: Introduction to plumbing and sanitary fittings.
2	Building Materials: Familiarization of various building materials- bricks, wood, steel and concrete with demonstration of its testing for fitness.
3	Calculate the area of a built-up space and a small parcel of land using standard measuring tape and digital distance measuring device.
4	Compute the area and/or volume of various building elements - door and window, quantity of bricks required to construct a wall of a building, quantity of steel bars used in windows (to create an awareness of measurements and units).
5	Setting out of a building: The student should set out a building (single room only) as per the given building plan using tape only.
6	Verification of triangle law of forces.

PART II

MECHANICAL WORKSHOP

(Five models from exercises 1 to 5 are mandatory. Additionally, the study and demonstration of the remaining exercises are also required.)

1	Carpentry: Study of Carpentry tools, Carpentry joints practices: T-Lap joint, Cross lap joint / Cross halving joint, Dove tail halving joint, Mortice & Tenon Joint.
2	Smithy: Study of different tools & forged models in Smithy shop, Forging Practices: Square prism, Hexagonal headed bolt, octagonal prism.
3	Foundry: Study of Foundry tools, Molding practices: Bench molding, Floor molding, Core making, Casting.
4	Fitting: Study of fitting tools in a workshop, Fitting shop joints practices: Square Joint, V-Joint, Male and Female fitting.
5	Welding: Study of welding tools, equipment's and methods, Welding practices: Arc Welding, MIG Welding, Oxy-Acetylene Gas Welding.
6	Conventional Machines: Study and demonstration of conventional machines like Shaping and Slotting machine, Lathe, Milling machine, Grinding machines & Radial drilling machine.
7	Advanced Manufacturing Methods: Study and demonstration of CNC machines and 3D printing.
8	Study and demonstration of pumps: Centrifugal, Self-priming and Reciprocating pumps. Study and demonstration of hydraulic turbines: Pelton, Francis and Kaplan Turbine.

Reference Books

1. S. C. Rangwala, *Water Supply and Sanitary Engineering*, Charotar Publishing House Pvt. Ltd., 28th ed., 2019.
2. A.K. Jain, *Basic Construction Materials*, Khanna Publishers, 1st ed., 2019.
3. S.K. Duggal, *Building Materials*, New Age International Publishers, 4th Edition, 2021.
4. M.S. Shetty and A.K. Jain, *Concrete Technology: Theory and Practice*, S. Chand & Company Pvt. Ltd., 9th ed., 2021.
5. B.C. Punmia, *Surveying*, Vol. 1, Laxmi Publications, 17th ed., 2021.
6. S.K. Garg, *Building Construction*, Khanna Publishers, 32nd ed., 2020.
7. W. A. J. Chapman, *Workshop Technology - Parts 1 & 2*, CBS Publishers & Distributors Pvt. Ltd., 4th ed., 2007.
8. A. O'Brien, (Editor), *Welding Handbook*, Vol. 1, 2, 3. American Welding Society, 9th ed., 2001.
9. J. Anderson, *Shop Theory*, Tata McGraw Hill, 6th ed. 2017.
10. J. H. Douglass, *Wood Working with Machines*, Illinois, McKnight & McKnight Pub. Co., 1995.
11. P.L. Jain, *Principles of Foundry Technology*, Tata McGraw Hill, 5th ed. 2017.
12. S.K. Hajra Choudhury, *Elements of Workshop Technology*, Vol 2, Media Promoters & Publishers, 2010.

B24EE1L02	ELECTRONIC CIRCUITS LAB I	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

The electronic circuits lab aims to equip the students with the basics of implementation of electronic circuits. It covers the design and implementation of wave shaping circuits and transistor-based circuits. This course builds a solid foundation that empowers to analyze and comprehend the application of electronic circuits.

Prerequisite

Electronic Circuits I

Course Outcomes

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

CO 1	Identify and test various electronic components and fabricate single-sided PCB. (Cognitive Knowledge Level: Understand)
CO 2	Design and test differentiator, integrator, clipping, clamping, and rectifier circuits. (Cognitive Knowledge Level: Apply)
CO 3	Design and set up voltage regulator, transistor-based amplifier, oscillator, and multivibrator circuits. (Cognitive Knowledge Level: Apply)
CO 4	Design and simulate simple circuits using PSpice with OrCAD Capture. (Cognitive Knowledge Level: Apply)
CO 5	Develop team management skills and prepare laboratory reports that logically and scientifically communicate experimental information. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Mark Distribution

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

Continuous Internal Evaluation Pattern

Attendance	10 marks
Continuous Assessment	15 marks
Performance	10 marks
Viva-Voce	5 marks
Lab Record	5 marks
Internal Exam	20 marks

End Semester Examination (ESE) Pattern

The following guidelines should be followed regarding the award of marks

1. Preliminary work : 25 Marks
 - (a) Circuit Diagram: 15 Marks
 - (b) Theory and Procedure: 10 Marks
2. Implementing the work/Conducting the experiment : 30 Marks (usage of equipment and troubleshooting)
3. Result and Inference : 15 Marks
4. Viva Voce : 30 Marks

SYLLABUS

LIST OF EXPERIMENTS

1	a) Familiarization/Identification of electronic components, testing instruments, and commonly used tools. b) Study Functionality, type, size, color coding, package, symbol, cost [Active, Passive components], Multimeter, Function generator, Power supply, and DSO.
2	a) Study the types of Printed circuit boards (PCB) (single-sided double-sided, PTH), Processing methods. b) Design and fabricate a single-sided PCB for a simple circuit with manual etching (Ferric chloride) and drilling.
3	a) Design and realize the integrator and differentiator circuits. b) Design and set up different types of clipping and clamping circuits.
4	a) Design and test half wave rectifier circuit with and without filter and plot the regulation characteristics. b) Design and test full wave rectifier circuit (center tapped and bridge circuit) with and without filter delivering 200 mA at 9V dc and plot the regulation characteristics.
5	a) Design and set up a transistor series regulated power supply and plot the regulation characteristics. b) Design and set up transistor sweep generator.
6	Design and set up an RC-coupled amplifier using BJT in CE configuration. Plot the frequency response characteristics and measure the gain and bandwidth.
7	a) Design and set up an RC phase shift oscillator for a frequency of 1 kHz. b) Design and set up an LC Oscillator and determine the inductance value used.
8	Design and set up an Astable Multivibrator for a frequency of 1 kHz.

9	Design and set up a Monostable Multivibrator for a frequency of 1kHz.
10	Study PSpice Software and simulate simple circuits using PSpice with OrCAD Capture.

Reference Books

1. Chinmoy Saha, Arindham Halder and Debarati Ganguly, *Basic Electronics - Principles and Applications*, Cambridge University Press, 1st ed., 2018.
2. Michael Dsouza and Dsouza Michael, *PCB Design: Printed Circuit Board*, Kindle Edition, 1st ed., 2017.
3. Bell D. A., *Electronic Devices and Circuits*, Prentice Hall of India, 11th ed., 2015.
4. Malvino A. and D. J. Bates, *Electronic Principles*, Tata McGraw Hill, 7th ed., 2017.
5. Boylestad R. L. and L. Nashelsky, *Electronic Devices and Circuit Theory*, Pearson Education India, 11th ed., 2015.
6. Floyd T.L., *Fundamentals of Analog Circuits*, Pearson Education, 2nd ed., 2012.
7. Anant Agarwal, Jeffrey Lang, *Foundations of Analog Electronic Circuits*, Morgan Kaufmann Publishers, 1st ed., 2005.

B24PC1L01A	PHYSICS(A) AND CHEMISTRY LAB(A)	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		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:

CO 1	Develop analytical/experimental skills and impart prerequisite hands-on experience for engineering laboratories. (Cognitive Knowledge Level: Apply)
CO 2	Understand the need for precise measurement practices for data recording. (Cognitive Knowledge Level: Apply)
CO 3	Understand the principle, concept, working and applications of relevant technologies and compare results with theoretical calculations. (Cognitive Knowledge Level: Apply)
CO 4	Understand and practice fundamental techniques in chemistry to generate experimental skills. (Cognitive Knowledge Level: Apply)
CO 5	Learn to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments. (Cognitive Knowledge Level: Apply)
CO 6	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 college)	30 marks

End Semester Examination Pattern

The college will internally conduct the end semester examination. Separate ESE's will be held for the Engineering Physics Lab and Engineering Chemistry Lab, each in the form of a 30 minutes written objective examination. The total marks for this course will be equally divided between the Physics 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, and 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, and Sabu Thomas, *Colloidal metal Oxide Nanoparticles: Synthesis, Characterization and Applications*, Elsevier Science, 2019.

B24MC1T03	PROFESSIONAL COMMUNICA- TION 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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
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 (% Marks)
	Test (% 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*, McGraw Hill Education, 2nd ed., 2017.
2. Meenakshi Raman and Sangeetha Sharma, *Technical Communication: Principles and Practice*, Oxford University Press, 2nd ed., 2011.
3. M. Govindarajan, S. Natarajan and V. S. Senthil Kumar, *Engineering Ethics*, Prentice-Hall of India, 2012.
4. R S Naagarazan, *A textbook on professional ethics and human values*, New Age International, 2006.

Reference Books

1. *English for Engineers and Technologists*, (Combined edition, Vol.1 and 2), Orient Blackswan, 2010.
2. Stephen P. Robbins and Phillip L.Hunsaker, *Training in Interpersonal Skills: Tips for Managing People at Work*, Pearson Education, India, 6th ed., 2015.
3. Mike W Martin and Roland Schinzinger, *Ethics in Engineering*, Tata McGraw Hill, 4th ed., 2014.
4. Charles D Fleddermann, *Engineering Ethics*, Pearson Education/ Prentice Hall of India, 2004.
5. 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

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Communication Process	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
	Module 2: Professional Discipline	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
	Module 3: Fundamentals of Ethical Engineering	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
	Module 4: Professional Responsibility in a Global Context	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 ATHANASIOUS 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 marks)

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

(8 marks)

OR

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

OR

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

B24MC1L02	IDEA LAB	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	3	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 Microcontroller 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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
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		

Mark Distribution

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.

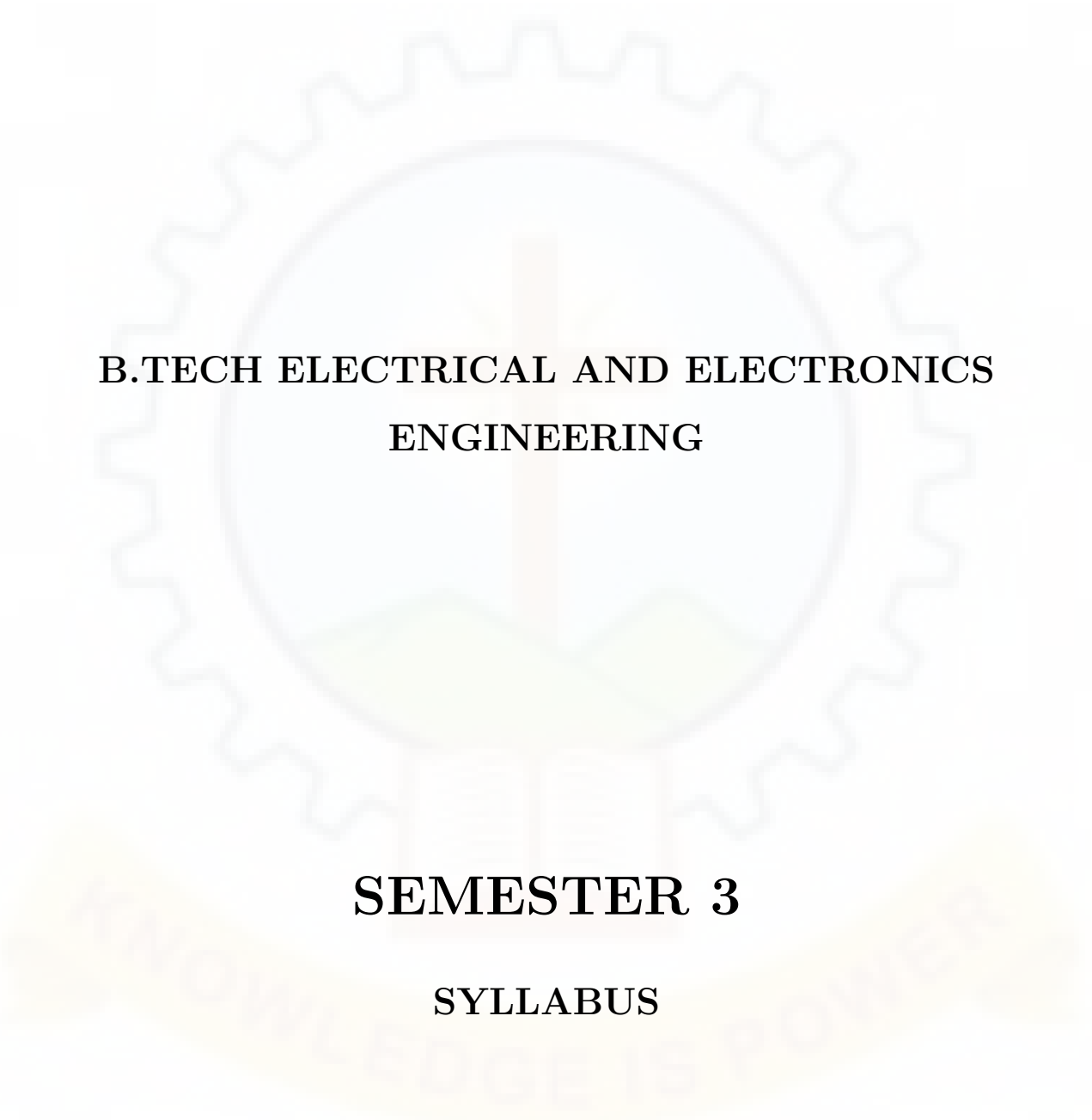
Reference Books

1. Veeranna D.K. *Workshop/Manufacturing Practices(with Lab Manual)|AICTE Prescribed Textbook (English)*, Khanna Book Publishing.
2. Dr. SabrieSoloman, *3D Printing and Design*, Khanna Book, ISBN: 978-9386173768.
3. Chris Hackett, *The Big Book of Maker Skills: Tools and Techniques for Building Great Tech Projects*, Weldon Owen, 2018, ISBN-13: 978-1681884325.
4. Sean Michael Ragan, *The Total Inventors Manual (Popular Science): Transform Your Idea into a Top Selling Product*, Weldon Owen, 2017, ISBN-13:978-1681881584.
5. Charles Platt, *Make: Tools: How They Work and How to Use Them*, Shroff/Maker Media, 2018, ISBN-13: 978- 352137374.
6. Paul Horowitz and Winfield Hill, *The Art of Electronics*, Cambridge University Press, 3rd ed., ISBN: 9780521809269.
7. Paul Sherz and Simon Monk, *Practical Electronics for Inventors* McGraw Hill, 4th ed., ISBN-13: 978-1259587542.
8. Charles Platt, *Encyclopedia of Electronic Components* (Volume 1, 2 and 3), Shroff Publishers. ISBN-13: 978-9352131945, 978-9352131952, 9789352133703.
9. John H. Moore, Christopher C. Davis, Michael A. Coplan and Sandra C. Greer, *Building Scientific Apparatus*, Cambridge University Press, 4th ed., ISBN-13: 978-0521878586.
10. Simon Monk, *Programming Arduino: Getting Started with Sketches*, McGraw Hill, 2nd ed., ISBN-13: 978-1259641633.
11. Simon Monk and Duncan Amos, *Make Your Own PCBs with EAGLE: From Schematic Designs to Finished Boards*, McGraw Hill Education, ISBN-13: 978-1260019193.
12. Scott Chacon and Ben Straub, *Pro GIT*, 2nd ed., Apress, 2014, ISBN-13: 9781484200773.
13. Venuvinod, P. K. and Ma W., *Rapid Prototyping – Laser Based and Other Technologies*, Kluwer.
14. Ian Gibson, David W. Rosen, and 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 ed., 2002.

MAR ATHANASIOUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution

Kothamangalam, Kerala, India



**B.TECH ELECTRICAL AND ELECTRONICS
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	B24EE2T01	CIRCUITS AND NETWORKS	2-2-0-5	4	4
C	B24EE2T02	ELECTRICAL MACHINES I	2-2-0-5	4	4
D	B24EE2T03	DIGITAL ELECTRONICS	2-1-0-4	3	3
E	B24EE2T04	ELECTRONIC CIRCUITS II	2-1-0-4	3	3
G	B24EE2L03	ELECTRICAL MEASUREMENTS LAB	0-0-3-2	3	2
H	B24EE2L04	DIGITAL ELECTRONICS LAB	0-0-3-2	3	2
I	B24MC2T04	UNIVERSAL HUMAN VALUES 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	B24EEM3X	MINOR	3-1-0-5	4	4
TOTAL				32	22

MINOR

COURSE NO.	COURSES
BASKET 1	
B24EEM31	CIRCUIT THEORY
BASKET 2	
B24EEM32	ELECTRIC CIRCUITS
BASKET 3	
B24EEM33	INTRODUCTION TO POWER ENGINEERING

B24MA2T03A	COMPLEX VARIABLES AND APPLICATIONS OF PDE	L	T	P	S	CREDIT	YEAR OF 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:

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

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.

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.

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.

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 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
	Total Hours	45 Hours
	Module 1: Partial Differential Equations	9
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
	Module 2: Applications of Partial Differential Equations	9
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
	Module 3: Complex Variable – Differentiation	9
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

	Module 4: Complex Variable – Integration	9
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
	Module 5: Complex Variable – Residue Integration	9
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

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Form the partial differential equation given $z = f(x + it) + g(x - it)$, where $i = \sqrt{-1}$.
2. 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°C and 80°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°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 $z = -1$.

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg. No.:

Name:

MAR ATHANASIOUS 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°C and 80°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 $f(z) = \begin{cases} \frac{\text{Re}(z)}{1-|z|}, & z = 0 \\ 0, & z \neq 0 \end{cases}$
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°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)

B24EE2T01	CIRCUITS AND NETWORKS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	2	0	5	4	2024

Preamble

This course aims to equip students with a comprehensive understanding of circuit analysis, focusing on both time-domain and frequency-domain methods, as well as the application of Laplace transforms in solving complex electrical circuits. The course covers key topics such as DC and AC circuit analysis, resonance, coupled circuits, three-phase systems, and two-port networks, alongside practical tools like MATLAB and PSpice for simulation. Upon completion, students will be capable of analyzing and solving complex electrical circuits and applying network analysis methods to real-world electrical engineering problems.

Prerequisites

Introduction to Electrical Engineering, Ordinary Differential Equations and Transforms.

Course Outcomes

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

CO 1	Solve electric circuits under various switching conditions to determine transient and steady-state behavior in the time domain. (Cognitive Knowledge Level: Apply)
CO 2	Apply and solve first and second-order DC circuits using Laplace transforms, considering various initial conditions and damping effects. (Cognitive Knowledge Level: Apply)
CO 3	Solve AC circuits and coupled circuits with sinusoidal excitation using Laplace transforms and s-domain analysis. (Cognitive Knowledge Level: Apply)
CO 4	Analyse resonance in RLC circuits and solve unbalanced three-phase systems using appropriate methods. (Cognitive Knowledge Level: Apply)
CO 5	Evaluate parameters of two-port networks and use transformations to solve network 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	3	2	1	2	2	2	1	1	1		2
CO 2	3	2	1	2	2	2	1	1	1		2
CO 3	3	2	1	2		2	1		1		2
CO 4	3	2	1	2		2	1		1		2
CO 5	3	2	1	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/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)

Time Domain Analysis of First and Second-Order Circuits

Behavior of R, L, C under switching conditions, time domain analysis of simple RL, RC, RLC series and parallel networks with excitation and initial conditions - transient and steady-state response - time constant - underdamped, critically damped, overdamped and undamped RLC network.

Use simulation software like MATLAB/PSpice to simulate RLC circuits (Assignment/Tutorial only).

MODULE 2 (9 hours)

DC Circuit Analysis in the Frequency Domain

Laplace transform of basic functions, properties - linearity, time shifting, frequency shifting, time scaling, time reversal, differentiation, integration, multiplication, convolution theorems - initial and final value theorem, solution of ordinary differential equation using Laplace transforms, inverse Laplace transform - partial fraction method.

S-domain analysis of circuits - Solution of simple RL, RC, and RLC DC networks using Laplace transforms, transformed equivalent of resistance, inductance, and capacitance - concept of the transformed circuit in s-domain - nodal analysis and mesh analysis of the transformed circuit.

MODULE 3 (10 hours)

AC Circuit Analysis in the Frequency Domain

Solution of RL, RC, and RLC circuits with sinusoidal excitation using Laplace Transforms, transformed circuits in s-domain - solution using mesh and nodal analysis.

Coupled circuits - Conductively coupled circuits and mutual impedance - mutual inductance, dot polarity convention, coefficient of coupling - series and parallel coupled circuits, analysis of coupled circuits in s-domain.

MODULE 4 (8 hours)

Resonance in an RLC Circuit

Resonance in series RLC circuits - impedance, phase angle, current, voltage, bandwidth, quality factor. Parallel resonance circuits (Concept only), resonant frequency for a tank circuit.

Unbalanced 3-Phase Systems

Three-phase networks - Unbalanced three-phase three-wire star and delta-connected load, four-wire unbalanced star-connected load, star-delta method of solving unbalanced load, neutral shift.

MODULE 5 (9 hours)

Two-port Networks

One-port network, two-port networks - Characterization in terms of impedance (Z), admittance (Y), hybrid (h) and transmission (T) parameters - conditions for symmetry and reciprocity of two-port networks, interconnection of two-port networks - series, parallel, and cascade, T- π representations and transformation.

Text Books

1. Hayt W. H., Kemmerly J. E., and Durbin S. M., *Engineering Circuit Analysis*, Tata McGraw Hill, 10th ed., 2023.
2. K. S. Suresh Kumar, *Electric Circuit Analysis*, Pearson Publications, 2nd ed., 2020.
3. Alexander and Sadiku, *Fundamentals of Electric Circuits*, McGraw-Hill, 6th ed., 2021.
4. Allan H. Robbins, Wilhelm C. Miller, *Circuit Analysis: Theory and Practice*, Cengage Learning, 5th ed., 2016.

Reference Books

1. Joseph A. Edminister and Mahmood Nahvi, *Theory and Problems in Electric circuits*, McGraw Hill, 5th ed., 2010.
2. A. Sudhakar, Shyammohan S Palli, *Circuits and Networks*, McGraw Hill, 4th ed., 2019.
3. Van Valkenberg, *Network Analysis*, Prentice Hall India Learning Pvt. Ltd., 3rd ed., 2018.
4. Chakrabarti, *Circuit Theory Analysis and Synthesis*, Dhanpat Rai and Co., 7th ed., 2021.
5. R. Gupta, *Network Analysis and Synthesis*, S. Chand and Company Ltd, 2nd ed., 2020.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Time domain Analysis of First and Second-Order Circuits	9
1.1	Behaviour of R, L, C under switching conditions	1
1.2	Time domain analysis of simple RL series and parallel networks with excitation and initial conditions	1
1.3	Time domain analysis of simple RC series and parallel networks with excitation and initial conditions	1
1.4	Time domain analysis of simple RLC series and parallel networks with excitation and initial conditions	2
1.5	Transient and steady-state response - time constant	1
1.6	Underdamped and critically damped RLC network	1
1.7	Overdamped and undamped RLC network	2
	Module 2: DC Circuit Analysis in the Frequency Domain	9
2.1	Laplace transform of basic functions, properties - linearity, time shifting, frequency shifting, time scaling, time reversal	1
2.2	Differentiation, integration, multiplication, and convolution theorems - initial and final value theorem	1
2.3	Solution of ordinary differential equation using Laplace transforms, inverse Laplace transform - partial fraction method for inverse Laplace transforms of functions	1
2.4	Solution of simple RL DC networks using Laplace transforms	1
2.5	Solution of simple RC DC networks using Laplace transforms	1
2.6	Solution of simple RLC DC networks using Laplace transforms	1
2.7	Transformed equivalent of resistance, inductance, and capacitance - concept of the transformed circuit in s-domain	1
2.8	Node analysis and mesh analysis of the transformed circuit	2
	Module 3: AC Circuit Analysis in the Frequency Domain	10
3.1	Solution of RL circuits with sinusoidal excitation using Laplace transforms	1
3.2	Solution of RC circuits with sinusoidal excitation using Laplace transforms	1
3.3	Solution of RLC circuits with sinusoidal excitation using Laplace transforms	1
3.4	Transformed circuits in s-domain	1
3.5	Solution using mesh and nodal analysis	1
3.6	Conductively coupled circuits and mutual Impedance	1

3.7	Mutual inductance, dot polarity convention	1
3.8	Coefficient of coupling - series and parallel coupled circuits	1
3.9	Analysis of coupled circuits in s-domain	2
	Module 4: Resonance in an RLC Circuit and Unbalanced 3-Phase Systems	8
4.1	Resonance in series RLC circuits - impedance, phase angle, current, voltage, bandwidth, quality factor	2
4.2	Parallel resonance circuits (Concept only), resonant frequency for a tank circuit	2
4.3	Unbalanced three-phase three-wire star connected load	1
4.4	Unbalanced three-phase three-wire delta connected load	1
4.5	Four-wire unbalanced star-connected load, star-delta method of solving unbalanced load, neutral shift	2
	Module 5: Two-port Networks	9
5.1	One-port network, two-port networks	1
5.2	Characterization in terms of impedance (Z) and admittance (Y) parameters	2
5.3	Characterization in terms of hybrid (h) and transmission (T) parameters	2
5.4	Conditions for symmetry and reciprocity of two-port networks	1
5.5	Interconnection of two-port networks series and parallel networks	1
5.6	Interconnection of two-port networks cascade networks	1
5.7	T- π representations and transformation	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Describe the transient and steady-state behaviour of resistors, inductors, and capacitors in various circuit configurations when subjected to switching conditions.
2. Solve for the time-domain responses of simple RL, RC, and RLC circuits using differential equations and initial conditions.
3. Derive the transient and steady-state response expressions in RL, RC and RLC circuits.
4. Classify RLC circuits as underdamped, critically damped, overdamped, or undamped based on their natural frequency and damping factor.

Course Outcome 2 (CO 2)

1. Evaluate the Laplace transform of basic functions and the properties of Laplace transforms.
2. Solve ordinary differential equations using Laplace transforms.
3. Find inverse Laplace transforms using the partial fraction method.
4. Use Laplace transforms to solve simple RL, RC, and RLC DC circuits in the s-domain.
5. Identify and calculate the transformed equivalent of resistance, inductance, and capacitance in the s-domain.
6. Apply node analysis and mesh analysis techniques to solve DC circuits in the transformed circuit in the s-domain.

Course Outcome 3 (CO 3)

1. Problems with steady state and transient analysis of RL, RC, and RLC series circuits with sinusoidal excitation.
2. Problems with node and mesh analysis of transformed circuits in the s-domain.
3. Problems on the solution of transformed circuits, including mutually coupled circuits in the s-domain.

Course Outcome 4 (CO 4)

1. Problems with unbalanced Y and Δ configurations.
2. Evaluation of neutral shift voltage in unbalanced systems.
3. Problems with series resonance circuits and evaluate the parameters such as quality factor, and bandwidth.
4. Develop the impedance/admittance *vs* frequency plot for the given RLC network.

Course Outcome 5 (CO 5)

1. Problems in finding Z, Y, h, and T parameters of simple two-port networks.
2. Problems with T- Δ transformation in two-port networks.
3. Derive the condition for symmetry and reciprocity of a two-port network.
4. Show that the overall transmission parameter matrix for the cascaded two-port network is simply the matrix product of transmission parameters for each individual two-port network in cascade.

MODEL QUESTION PAPER

QP CODE:

Pages: 4

Reg. No.:

Name:

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),
KOTHAMANGALAM

THIRD SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: : B24EE2T01

Course Name: CIRCUITS AND NETWORKS

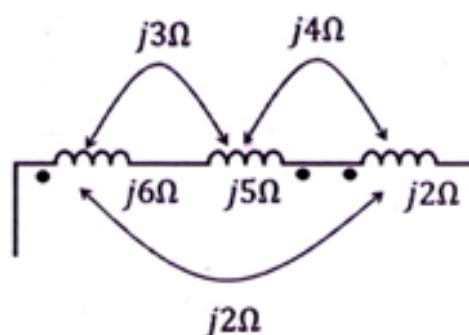
Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. A series RL circuit with $R = 20 \Omega$ and $L = 10 H$ has a constant voltage, $V = 40 V$ applied through a switch S at $t = 0$. Solve for the current equation in the network.
2. Evaluate the time constant of a series RC circuit with $R = 10 \Omega$ and $C = 1 F$.
3. Determine the s-domain equivalent circuit of an inductor with an initial I_o current
4. State initial value theorem in Laplace transforms.
5. Obtain the sinusoidal response of an RL series circuit with initial conditions equal to zero.
6. Obtain the equivalent inductive reactance.

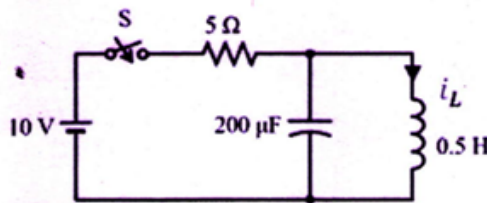


7. Line currents through a 3-phase 4-wire unbalanced star-connected load are $I_A = 9.24 \angle 0^\circ$ A, $I_B = 21 \angle -100^\circ$ A and $I_C = 15.4 \angle 110^\circ$ A. Find the current through the neutral wire.
8. Explain the condition for resonance and Quality factor in series RLC circuit.
9. Two identical sections of transmission lines with $A = 2$, $B = 3$, $C = 1$, $D = 2$ parameters are cascaded. Calculate the transmission parameters of the resultant network.
10. A two-port network is described by the equation, $V_1 = 4I_1 + 2I_2$ and $V_2 = 2I_1 + I_2$. A load impedance of 3Ω is connected to port 2. Calculate the value of input impedance.

PART B

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

11. In the network shown in the figure below, initially, the switch S is closed and a steady state is obtained. At $t = 0$, switch S is opened.
 - (a) Determine the current $I_L(t)$ through the inductor. (10 marks)
 - (b) Determine the voltage across the capacitor and draw the final steady-state circuit. (4 marks)

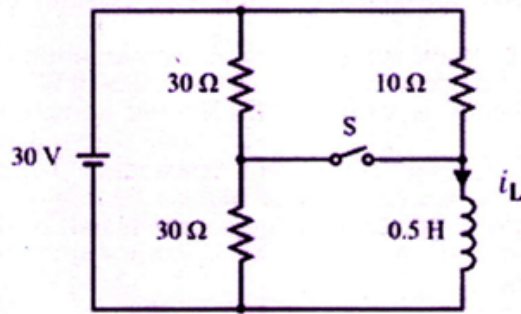


OR

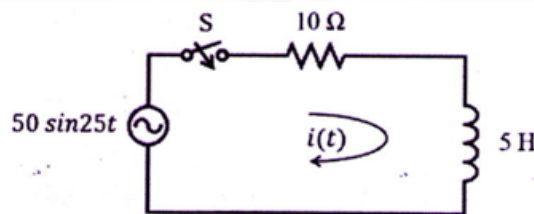
12.
 - (a) Derive the expression of current in an underdamped RLC series network with dc excitation. (10 marks)
 - (b) A series RC circuit is connected to a DC source of 10 V at time $t = 0$. Find the voltage across the capacitor at $t = 1$ sec, if the time constant of the circuit is 2 seconds. (4 marks)
13.
 - (a) State and prove the time shifting theorem with Laplace transforms (5 marks)
 - (b) Find the current equation in an series RLC DC circuit. (9 marks)

OR

14. In the circuit given below, obtain $I_L(t)$ when
 - (a) Switch S is initially open and closed at $t = 0$. (8 marks)
 - (b) Switch S is initially closed and opened at $t = 0$. (6 marks)



15. (a) Using Laplace transform technique, determine the current $I(s)$ in the network given below when the switch is closed at $t = 0$. Assume the inductor is initially relaxed. (4 marks)

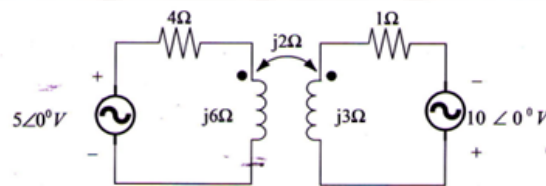


- (b) Explain Dot rule and the coefficient of coupling in coupled circuits. (10 marks)

OR

16. For the circuit given below

- (a) Find the steady state current through the 1Ω and 4Ω resistors. (8 marks)
 (b) Obtain the conductively coupled equivalent circuit. (6 marks)



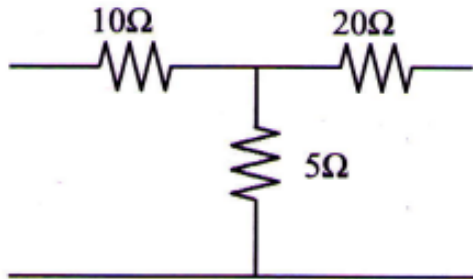
17. A 400V, three-phase balanced supply feeds a delta-connected load having phase impedances $Z_{RY} = 40 \angle 30^\circ$, $Z_{YB} = 50 \angle 0^\circ$ and $Z_{BR} = 40 \angle -30^\circ$. Determine the following:
 (a) Phase currents and line currents (10 marks)
 (b) Active and reactive power delivered to the load. (4 marks)

OR

18. (a) Explain neutral shift in a three-phase unbalanced star-connected load. (4 marks)

- (b) A 440 V, 50 Hz, 3 phase supply of phase sequence ABC is supplied to a star connected load with branch impedances $Z_A = 10 \Omega$, $Z_B = -j5 \Omega$, $Z_C = -j5 \Omega$. Calculate line currents and voltage across each phase impedance. The phase sequence is ABC. (8 marks)

19. (a) Determine the h parameters of the following network (8 marks)



- (b) Derive the condition for symmetry and reciprocity of a two-port network in terms of transmission parameters (6 marks)

OR

20. (a) Show that the Y parameters of two parallel connected two port networks is equal to the sum of their individual Y parameters. (6 marks)
- (b) A two-port network is represented by the following network equations. $V_1 = 4I_1 + 2I_2$ and $V_2 = 2I_1 + I_2$. Determine the equivalent π network. (8 marks)

B24EE2T02	ELECTRICAL MACHINES I	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	2	0	5	4	2024

Preamble

The course provides fundamental knowledge of electromechanical energy conversion, focusing on the principles, construction, operation, and performance analysis of DC machines and transformers. The course explores the working principles, characteristics, and real-world applications of DC generators, DC motors, and transformers, including their efficiency, losses, and testing methods. By the end of the course, students will be able to analyse, troubleshoot, and optimize the performance of DC machines and transformers, apply appropriate testing methods, and understand their applications.

Prerequisite

Introduction to Electrical Engineering

Course Outcomes

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

CO 1	Illustrate the constructional details of DC machines and explain the working principle of DC generators and classify them. (Cognitive knowledge Level: Understand)
CO 2	Analyse the performance of DC generators under different load conditions and interpret the conditions for voltage build-up. (Cognitive knowledge Level: Apply)
CO 3	Describe the principle of operation of DC motors, test DC machines to assess its performance, and select appropriate motor types for different applications. (Cognitive knowledge Level: Apply)
CO 4	Construct the phasor diagram and equivalent circuit of single-phase transformers and investigate the conditions for parallel operation of transformers. (Cognitive knowledge Level: Apply)
CO 5	Explain the theory of autotransformers, and analyse three-phase transformer connections with their vector groupings for effective power system integration. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% 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/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 (8 hours)

Introduction to DC Machines

Constructional details of DC machines, armature winding - single layer - double layer - lap and wave windings, equalizer rings, dummy coils - developed simplex winding diagram - double layer - progressive only (winding diagram not for evaluation).

DC generator - principle of operation, EMF equation, classification of DC generator, numerical problems.

MODULE 2 (10 hours)

Characteristics of DC Generators

Armature reaction - demagnetising and cross-magnetising ampere turn, commutation - compensating windings, interpoles. DC shunt generator - voltage build-up, no-load characteristics (OCC) - critical field resistance - critical speed, numerical problems, load characteristics of DC shunt and compound generators. Power flow diagram - losses and efficiency - maximum efficiency, parallel operation - load sharing, numerical problems.

MODULE 3 (10 hours)

DC Motors

DC motor - principle of operation - back emf, classification of DC motors, numerical problems. Torque equation, performance characteristics, numerical problems. Starting of DC motors, starters - 3-point and 4-point starters (principle only). Speed control of DC motors - field control, armature control, numerical problems. Power flow diagram - losses and efficiency, numerical problems. Testing of DC motors - Swinburne's test, Hopkinson's test, Retardation test, numerical problems, DC motor applications.

MODULE 4 (10 hours)

Single-Phase Transformers

Single-phase transformers - constructional details, principle of operation, EMF equation. Ideal and practical transformer - phasor diagram, no load and on load operations, equivalent circuit, voltage regulation, numerical problems. Transformer losses and efficiency, condition for maximum efficiency, kVA rating, numerical problems. Testing of transformers - polarity test, open circuit test, short circuit test, Sumpner's test - separation of losses, parallel operation of single-phase transformers, numerical problems.

MODULE 5 (8 hours)

Autotransformers and Three-Phase Transformers

Autotransformer - principle of operation, rating of autotransformers. Three-phase transformer - construction, different connections of 3-phase transformers - $Y - Y$, $\Delta - \Delta$, $Y - \Delta$, $\Delta - Y$, numerical problems. Vector groupings - need for vector grouping - $Yy0$, $Dd0$, $Yy6$, $Dd6$, $Yd1$, $Yd11$, $Dy1$, $Dy11$. Parallel operation of three-phase transformers - essential and desirable conditions. Power transformer and distribution transformer - all-day efficiency, numerical problems.

Text Books

1. V. K. Mehta and Rohit Mehta, *Principles of Electrical Machines*, S. Chand Publication, 2006.
2. K. Murugesh Kumar, *DC Machines & Transformers*, Vikas Publishing House, 2nd ed., 2008.
3. J. B. Gupta, *Theory & Performance of Electrical Machines*, S. K. Kataria, 15th ed., 2022.
4. Vinod Kumar and K. S. Suresh Kumar, *Electric Machines*, McGraw-Hill Education, 2018.

Reference Books

1. P. S. Bimbhra, *Electrical Machinery*, Khanna Publishers, 7th ed., 2021.
2. D. P. Kothari & I J Nagrath, *Electric Machines*, Tata McGraw Hill, 5th ed., 2017.
3. Stephen L. Herman, *Electrical Transformers and Rotating Machines*, Cengage Learning, 4th ed., 2016.
4. A. E. Fitzgerald, Charles Kingsley Jr., and Stephen D. Umans *Electric Machinery*, McGraw Hill, 7th ed., 2013.
5. A. E. Clayton & N. N. Hancock, *The Performance and design of Direct Current Machines*, CBS Publishers & Distributors, New Delhi, 2018.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	46 Hours
	Module 1: Introduction to DC Machines	8
1.1	Constructional details of DC machines	1
1.2	Armature winding- single layer - double layer - lap and wave windings, equalizer rings, dummy coils	1
1.3	Developed simplex winding diagram-double layer - progressive only	2
1.4	DC generator - principle of operation, EMF equation - numerical problems	2
1.5	Classification of DC generator - numerical problems	2
	Module 2: Characteristics of DC Generators	10
2.1	Armature reaction - demagnetising and cross magnetising ampere turns	1
2.2	Commutation - compensating windings, interpoles	1
2.3	DC Shunt Generator - no-load characteristics (OCC) - voltage build-up - critical field resistance - critical speed - numerical problems	2
2.4	Load characteristics of DC shunt and compound generators	2
2.5	Power flow diagram - losses and efficiency - maximum efficiency - numerical problems	2
2.6	Parallel operation - load sharing - numerical problems	2
	Module 3: DC Motors	10
3.1	DC motor - principle of operation - back emf	1
3.2	Classification of DC motors - numerical problems	1
3.3	Torque equation - numerical problems	1
3.4	Performance characteristics of DC shunt and series motors	1
3.5	Starting of DC motors - starters – 3-point and 4-point starters	1
3.6	Speed control of DC motors - field control, armature control - numerical problems	1
3.7	Power flow diagram - losses and efficiency - numerical problems	2
3.8	Testing of DC motors - Swinburne's test - numerical problems	1
3.9	Hopkinson's Test - Retardation test - DC motor applications	1
	Module 4: Single-Phase Transformers	10
4.1	Single-phase transformers - constructional details - principle of operation	1
4.2	EMF equation - numerical Problems	1

4.3	Ideal and practical transformer - phasor diagram, no-load and on-load operations	1
4.4	Equivalent circuit, voltage regulation - numerical problems	2
4.5	Transformer losses and efficiency, condition for maximum efficiency - numerical Problems - kVA rating.	2
4.6	Testing of transformers - polarity test, open circuit test, short circuit test - numerical problems	1
4.7	Sumpner's test - separation of losses	1
4.8	Parallel operation of single-phase transformers - numerical problems	1
	Module 5: Autotransformers and Three-phase Transformer	8
5.1	Autotransformer - saving of copper -rating of autotransformers	1
5.2	Three phase transformer - construction - different connections of 3-phase transformers - $Y-Y$, $\Delta-\Delta$, $Y-\Delta$, $\Delta-Y$	1
5.3	Numerical problems on $Y-Y$, $\Delta-\Delta$, $Y-\Delta$, $\Delta-Y$	1
5.4	Difference between power transformer and Distribution transformer - all-day efficiency - numerical problems	2
5.5	Vector groupings - Need for Vector Grouping - $Yy0$, $Dd0$, $Yy6$, $Dd6$, $Yd1$, $Yd11$, $Dy1$, $Dy11$	2
5.5	Parallel operation of three-phase transformers - essential and desirable conditions	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Describe the functions of individual parts of DC machines.
2. Develop simplex lap and wave windings for different pole configurations.
3. Explain different types of DC generators.
4. Derive the EMF equation of a DC machine.

Course Outcome 2 (CO 2)

1. Draw the open circuit and load characteristics of DC generators
2. Explain the conditions for voltage build up in DC generators.
3. Explain armature reaction in DC machines and solutions to overcome its effects.
4. Explain Commutation and ways to improve it.

5. Analyse parallel operation of DC generators.

Course Outcome 3 (CO 3)

1. Derive the torque equation of a DC motor.
2. Why starters are used in DC motors?
3. Explain the types of speed control in DC motor.
4. Explain regenerative braking in a DC motor.
5. What are the losses associated with DC motor?
6. Select a suitable type of DC motor for specific applications.

Course Outcome 4 (CO 4)

1. Derive the EMF equation of a single-phase transformer.
2. Derive the condition for maximum efficiency in a transformer.
3. What are the necessary condition for parallel operation of a single-phase a transformer?
4. Explain no-load and short circuit tests on a single-phase transformer.
5. Explain Sumpner's test on transformers.
6. Draw the equivalent circuit of single-phase transformer referred to the LV side.

Course Outcome 5 (CO 5)

1. Explain the theory of autotransformer.
2. Explain the different connections of 3-phase transformers.
3. Draw the Vector Groupings of a three-phase transformer.
4. What are the necessary conditions for parallel operation of three-phase transformers?
5. Compare power transformer and distribution transformer.
6. What is All Day Efficiency?

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg. No.:

Name:

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

THIRD SEMESTER B.TECH DEGREE EXAMINATION, December 2025

Course Code: : B24EE2T02

Course Name: : Electrical Machines I

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Compare Lap and Wave windings.
2. List down the classification of DC Generators.
3. A 4-pole generator has a wave wound armature with 722 conductors and delivers 100 A on full load. If the brush lead is 8° , calculate the armature demagnetizing and cross-magnetizing ampere turns per pole.
4. Explain the methods to improve commutation.
5. Explain the need for starters.
6. List down the speed control techniques of the DC Shunt motor.
7. Draw the phasor diagram of a single phase transformer with capacitive load.
8. In a 50 kVA transformer, the iron loss is 500 W and full-load copper loss is 800 W. Find the efficiency at quarter load and 0.8 pf lag.
9. Explain the essential and desirable conditions for the parallel operation of three-phase transformers.
10. An autotransformer supplies a load of 2.5 kW at 110 V at a unity power factor. If the applied primary voltage is 220 V, calculate the power transferred to the load inductively and conductively.

PART B

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

11. (a) Explain in detail the constructional details of a 4 pole DC machine. (8 marks)
- (b) A 20 kW, 250 V DC shunt generator has armature and field resistances of 0.1Ω and 125Ω respectively. Calculate the total armature power developed when running (i) as a generator delivering 20 kW output (ii) as a motor taking 20 kW input. (6 marks)

OR

12. A compound generator is to supply a load of 250 lamps, each rated at 100 W, 250 V. The armature, series field and shunt field windings have resistance of 0.06Ω , 0.04Ω , 50Ω respectively. Determine the generated emf when the machine is connected in i) long shunt ii) short shunt Take drop per brush as 1 V. Draw the circuit connections in each case. (14 marks)
13. A 100 kW, 460 V shunt generator was run as a motor on no-load at its rated voltage and speed. The total current taken was 9.8 A including a shunt current of 2.7 A. The resistance of the armature circuit (including compoles) at normal working temperature was 0.11Ω . Calculate the efficiency at (i) full-load (ii) half full-load. (14 marks)

OR

14. The O.C.C of a separately excited d.c. generator driven at 400 r.p.m. is as follows.

Field Current (A)	2	3	4	5	6	7	8	9
E.M.F (V)	110	155	186	212	230	246	260	271

The machine is connected as a shunt generator and driven at 400 r.p.m. Find,

- i. The emf to which the machine will excite when the field circuit resistance is 34Ω .
- ii. The critical value of shunt field resistance. Also, infer what happens if the field resistance value exceeds the critical value.
- iii. The critical speed when the field circuit resistance is 34Ω . (14 marks)
15. (a) A 220 V DC shunt motor runs at 1000 rpm while taking a current of 25 A. The resistance of armature is 0.2Ω and that of shunt field circuit is 110Ω . Calculate the speed when the load is increased so that the motor takes a load current of 50 A. During this increase in load, armature reaction weakens the field by 2 %. The average drop per brush is 1 V. Determine torque developed in both cases. (10 marks)
- (b) Explain any two braking techniques of DC Motor. (4 marks)

OR

16. (a) A 200 V shunt motor has an armature resistance of 0.1Ω and field resistance 240Ω and rotational loss 236 W. On full load the line current is 9.8 A with the motor running at 1450 rpm.

Calculate

- i. Mechanical power
 - ii. Output power
 - iii. Load torque
 - iv. Full load efficiency (8marks)
- (b) A 500 V DC shunt motor takes a current of 4 A on no-load. The armature resistance including that of brush is 0.2Ω and field current is 1 A. Estimate the output power and efficiency when input current is at 20 A. (6 marks)

17. A 20 kVA 250/2500 V 50 Hz single phase transformer gave the following test results.

OC TEST	220 V	1.4 A	150 W
SC TEST	120 V	8 A	320 W

Find the required parameters and hence draw the equivalent circuit of the transformer referred to LV side. Also predetermine the efficiency at 75 % rated load and regulation at half load, 0.8 pf lead. (14 marks)

OR

18. Explain the need for parallel operation of Single Phase Transformers. Derive the expression for load shared between 2 transformers. Also draw the circuit diagram to Back-to Back Test in 2 identical transformers. Explain how regulation can be determined from the same. (14 marks)
19. Derive an expression to justify the saving of copper in auto transformer with respect to an ordinary two winding transformer with the same rating. Also find the currents in different parts of the winding for a step down auto transformer from 440 V to 300 V supplying 30Ω load. (14 marks)

OR

20. Explain group 1, 3, and 4 vector groupings of three-phase transformers with phasor and winding connection diagrams. (14 marks)

B24EE2T03	DIGITAL ELECTRONICS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course aims to equip students with essential knowledge and practical skills in the design, analysis, and implementation of digital electronic systems. The course ensures a comprehensive understanding of the logic design of combinational and sequential circuits, state machines, and a hardware description language is introduced to model and simulate digital circuits. Students will gain analytical and practical expertise to understand and design digital electronic systems, making them well-prepared for both academic research and industry applications in digital electronics.

Prerequisites

Electronic Circuits I

Course Outcomes

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

CO 1	Understand various number systems, codes, and logic gates and perform binary arithmetic operations. (Cognitive Knowledge Level: Understand)
CO 2	Apply Boolean laws and theorems, utilize K-map for the minimization of Boolean expressions, and design digital circuits. (Cognitive Knowledge Level: Apply)
CO 3	Design and implement various combinational logic circuits for practical applications. (Cognitive Knowledge Level: Apply)
CO 4	Design and analyse various types of registers, asynchronous counters, and synchronous counters for sequential operations. (Cognitive Knowledge Level: Apply)
CO 5	Understand the operation of various ADC/DAC circuits, the concepts of Verilog HDL, and design State machines for various applications. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	1	1		2	1	2	1	1	2
CO 2	3	3	2	2	2	2	1	2	1	1	2
CO 3	3	3	2	2	2	2	1	2	1	1	2
CO 4	3	2	3	2	2	2	1	2	1	1	2
CO 5	3	3	3	2	2	2	1	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/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 (7 hours)

Number Systems, Codes and Logic Gates

Number systems and codes: Decimal, binary, octal and hexadecimal conversions - ASCII code, excess-3 code, gray code, BCD, error detection codes-parity method. Binary addition and subtraction - representation of signed numbers, 1's and 2's complement arithmetic, floating-point representation.

Logic gates, realization of NAND and NOR as universal gates.

MODULE 2 (8 hours)

Boolean Algebra

Boolean Laws and De Morgan's theorems, conversion of AOI logic to NAND/NOR logic-Sum of Products(SOP) method, Product of Sum(POS) method - K-map representation and simplification - pairs, quads, octets, don't care conditions.

MODULE 3 (7 hours)

Combinational Circuits

Adders - half adder and full adder, subtractors - half subtractor and full subtractor, 4 bit parallel binary adder/subtractor, carry look-ahead adders.

Comparators, parity generators and checkers, encoders, decoders, BCD to seven segment decoder, code converters, multiplexers, demultiplexers.

MODULE 4 (8 hours)

Sequential Circuits

Flip-Flops: SR, JK, D and T flip-flops, JK master slave flip-flop, conversion of flip-flops, preset and clear pins. Shift Registers: SISO, SIPO, PISO, PIPO.

Asynchronous counters: Up/Down counters - modulus of a counter - design of Mod-N counters, Ring counter, Johnson counter. Synchronous counters - design of synchronous counters.

MODULE 5 (6 hours)

D/A and A/D converters and State Machines

Digital to Analog converter(DAC): specifications, weighted resistor type and R-2R ladder type DAC. Analog to Digital Converter(ADC): specifications, flash type and successive approximation type ADC.

State Machines: State transition diagram, Moore and Mealy Machines.

Introduction to Verilog programming: Gate flow and data flow modelling of all the logic gates, half adder and full adder.

Text Books

1. Floyd T. L, *Digital Fundamentals*, Pearson Education, 11th ed., 2017.
2. Bhupesh Bhatia and M. V. Subramanyam, *Basics of Digital Electronics*, Tata McGraw-Hill Education, 8th ed., 2020.
3. Mano M. M, *Logic and Computer Design Fundamentals*, Pearson Education, 5th ed., 2016.
4. A. Anand Kumar, *Fundamental of Digital Electronics*, Prentice Hall, 5th ed., 2016.
5. S. Salivahanan, *Digital Circuits and Design*, Oxford University Press, 6th ed., 2018.

Reference Books

1. Donald P. Leach, Albert Paul Malvino, *Digital Principles and Applications*, McGraw Hill, 8th ed., 2016.
2. Tocci R. J. and N. S. Widmer, *Digital Systems, Principles and Applications*, Pearson Education, 11th ed., 2008.
3. John F. Wakerly, *Digital Design: Principles and Practices*, Pearson Education, 4th ed., 2005.
4. Taub & Schilling, *Digital Integrated Electronics*, McGraw Hill, 7th ed., 2017.
5. C. H. Roth and L. L. Kimney, *Fundamentals of Logic Design*, Cengage Learning, 7th ed., 2013.
6. Roy Chaudari, *Linear Integrated Circuits*, New Age International Publications, 5th ed., 2018.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Number Systems, Codes and Logic Gates	7
1.1	Decimal, binary, octal and hexadecimal conversions	2
1.2	ASCII code, excess-3 code, gray code, BCD, error detection codes - Parity method.	1
1.3	Binary addition and subtraction - representation of signed numbers	1
1.4	1's and 2's complement arithmetic	1
1.5	Floating-point representation	1
1.6	Logic gates, realization of NAND and NOR as universal gates	1
	Module 2: Boolean Algebra	8
2.1	Boolean Laws and De Morgan's theorems	2
2.2	Conversion of AOI logic to NAND/NOR logic	2
2.3	Sum of Products method	1
2.4	Product of Sum method	1
2.5	K map representation and simplification - pairs, quads, octets, don't care conditions	2
	Module 3: Combinational Circuits	7
3.1	Adders - half adder and full adder	1
3.2	Subtractors - half subtractor and full subtractor, 4-bit parallel binary adder/subtractor	1
3.3	Carry Look-ahead adders	1
3.4	Comparators, parity generators and checkers	1
3.5	Encoders, decoders, BCD to seven segment decoder, code converters	1
3.6	Multiplexers	1
3.7	Demultiplexers	1
	Module 4: Sequential Circuits	8
4.1	Flip-Flops: SR, JK, D and T flip-flops, JK master-slave Flip-flop	1
4.2	Conversion of flip-flops, preset and clear pins	1
4.3	Shift Registers : SISO, SIPO, PISO, PIPO	2
4.4	Asynchronous counters: Up/Down counters - modulus of a counter	1
4.5	Design of Mod-N counters - Ring counter, Johnson Counter	1
4.6	Synchronous counters, design of synchronous counters	2
	Module 5: D/A and A/D converters and state machines	6

5.1	Digital to Analog converter: Specifications, weighted resistor type and R-2R Ladder type DAC	1
5.2	Analog to Digital Converter: specifications, flash type, and successive approximation type ADC	1
5.3	State Machines: State transition diagram, Moore and Mealy Machines	2
5.4	Introduction to Verilog programming: gate flow and data flow modelling of all the logic gates, half adder and full adder	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Convert one number system to another form - binary, decimal, octal, and hexadecimal.
2. Explain error detection using the parity method.
3. Perform binary arithmetic using 1's complement and 2's complement method.

Course Outcome 2 (CO 2)

1. Reduce the boolean expression using Boolean laws.
2. Develop logic circuits using Universal gates.
3. Convert an SOP form to a POS form and vice-versa.
4. Simplify boolean expression using K-map.

Course Outcome 3 (CO 3)

1. Design of i) half adder ii) full adder iii) full subtractor using gate.
2. Discuss how the look-ahead carry adder speeds up the addition process.
3. Explain the use of the enable input in a decoder.
4. Explain odd parity generator and even parity generator.
5. Differentiate between multiplexers and de-multiplexers.

Course Outcome 4 (CO 4)

1. Explain different types of flip-flops and its application areas.
2. Describe a level triggered flip flop and compare it with an edge triggered flipflop.
3. Design of mod-N asynchronous counter using J-K flipflop.
4. Distinguish Ring counter from Johnson counter.
5. Explain various types of shift register.

Course Outcome 5 (CO 5)

1. Determine the number of output voltages that can be produced by an 8 bit ADC.
2. Write the advantage of the R-2R ladder DAC over the weighted resistor type DAC.
3. Differentiate between Moore and Mealy machine.
4. Explain the function of the Mealy machine.
5. Write the implementation code of simple circuits using Verilog.

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg. No.:

Name:

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),
KOTHAMANGALAM

THIRD SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: : B24EE2T03

Course Name: : DIGITAL ELECTRONICS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Find the binary code and gray code of the number 3A816.
2. Implement NOT circuit using a two input EX-OR gate.
3. Using the Boolean laws and rules, simplify the logic expression $Z = (A + B)(\bar{A} + B)$.
4. Convert the following function into standard POS and express as maxterms $Y(A, B, C) = (A + B)(\bar{B} + C)(A + C)$.
5. Implement $Y(A, B, C) = \Sigma m(0, 1, 2, 6, 7)$ using 4:1 MUX.
6. Design a 2 bit magnitude comparator using logic gates.
7. Derive the characteristic equation of a J-K flip-flop.
8. Determine the number of flip-flops needed to construct a register capable of storing
(i) a 6 bit binary number (ii) hexadecimal numbers upto F (iii) octal numbers upto 10.
9. Draw the circuit diagram of a 4-bit weighted resistor type digital to analog converter.
Write an expression for its output.
10. Write the structural model of three input AND gate in Verilog HDL.

PART B

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

11. (a) Perform $-25 + 14$ using 1's complement and 2's complement method. (7 marks)
(b) Draw the Truth table and explain the operation of Universal Gates. (7 marks)

OR

12. (a) Convert the following (9 marks)
i. $(1001011)_{gray} = ()_2$
ii. $(10110110.0011)_2 = ()_{BCD}$
iii. $(5762)_8 = ()_{16}$
iv. $(76)_{10} = ()_{gray}$
v. Attach the proper even parity bit to 10100100 and odd parity bit to 11111000.
(b) Convert the decimal number 3.248×10^4 to a single-precision floating-point binary number. (5 marks)

13. (a) Reduce the expression $Y = \sum m(0, 1, 2, 3, 5, 7, 8, 9, 10, 12, 13)$, show the implementation using NAND gates. (8 marks)
(b) Show that a full adder can be constructed with two half adders and an OR gate. (6 marks)

OR

14. (a) If $\bar{A}B + C\bar{D} = 0$, then prove that $AB + \bar{C}(\bar{A} + \bar{D}) = AB + BD + \bar{B}\bar{D} + \bar{A}\bar{C}D$ (4 marks)
(b) Explain the difference between ripple adder and carry look ahead adder with implementation details. (10 marks)
15. (a) Design two bit comparator using decoder. (8 marks)
(b) Draw the implementation circuit of a 1 : 8 Demultiplexer using two 1 : 4 demultiplexers. (8 marks)

OR

16. Write down the truth table for a BCD-to-seven segment decoder. Deduce the Boolean expression for each output. (14 marks)
17. (a) Draw the logic circuit diagram of a 4-bit ring counter which employs D flip-flop. Write down its count sequence table. (5 marks)
(b) Design a mod-10 asynchronous up-counter using J-K flip-flops. Draw the timing diagram and relevant excitation table. (9 marks)

OR

18. (a) Design a counter to produce the following binary sequence. Use J-K flip-flops.
1, 4, 3, 5, 7, 6, 2, 1, ... (9 marks)
- (b) Draw the circuit and timing diagrams of a 3 bit SISO shift register. (5 marks)
19. (a) Write the Verilog code for a half adder. (7 marks)
- (b) Explain R-2R ladder type of DAC. (7 marks)

OR

20. (a) Explain the working of successive approximation ADC with the help of an example. (8 marks)
- (b) Differentiate Moore and Mealy state machines. (6 marks)

B24EE2T04	ELECTRONIC CIRCUITS II	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course aims to impart sound knowledge and basic concepts of operational amplifiers. It gives information about the working principle and applications of analog electronic devices. This course will enable the students to develop the skill to design circuits using operational amplifiers and other linear ICs for various applications.

Prerequisites

Electronic Circuits I

Course Outcomes

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

CO 1	Understand the working principle of MOSFET and basic concepts of TTL and CMOS logic families. (Cognitive Knowledge Level: Understand)
CO 2	Understand the fundamentals of operational amplifiers and design Op-Amp circuits for various applications. (Cognitive Knowledge Level: Apply)
CO 3	Analyse the working principle of Op-Amp oscillators, multivibrators, and various filters. (Cognitive Knowledge Level: Apply)
CO 4	Analyse the working of 555 timer, VCO and PLL ICs and its applications. (Cognitive Knowledge Level: Apply)
CO 5	Understand the working principle of various voltage regulators. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	2	1	1	1	1		1		1
CO 2	3	2	1	2	3	1	1		1		1
CO 3	3	2	1	2	1	1	1		1		1
CO 4	3	2	1	2	1	1	1		1		1
CO 5	3	2	1	2	1	1	1		1		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/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 (8 hours)

MOSFET and MOSFET Amplifier

MOSFET: Structure - enhancement, and depletion types, the principle of operation, and characteristics. MOSFET as an amplifier, biasing of discrete MOSFET amplifier, small signal equivalent circuit, small signal voltage and current gain, input and output impedance of CS configuration.

TTL and CMOS Logic Families

Concepts of sourcing, sinking, fan-in, fan-out, internal diagram of TTL NAND gate and CMOS NOR gate.

MODULE 2 (8 hours)

Differential Amplifiers

Differential amplifier configurations using BJT - differential and common mode gains.

Operational Amplifiers

Block Diagram of Op-Amp, Characteristics of Op-Amp - gain, bandwidth, slew rate, CMRR, offset voltage, offset current, comparison of ideal and practical Op-Amp IC 741, open loop and closed loop configurations, concept of virtual ground.

Applications of Op-Amps - Inverting and non-inverting amplifier circuits, summing amplifier, subtractor, integrator, differentiator - practical integrator and differentiator circuits, comparator.

Use simulation software like MATLAB/PSpice to simulate basic Op-Amp circuits (Assignment/Tutorial only).

MODULE 3 (7 hours)

Op-Amp Oscillators and Multivibrators

Phase shift and Wien-bridge oscillators, triangular and sawtooth waveform generators, astable and monostable multivibrators.

Active Filters

Comparison with passive filters, first and second order low pass, high pass, band pass and band reject active filters, state variable filters.

MODULE 4 (7 hours)

Timer and VCO

Timer IC 555 - functional diagram, astable and monostable operations, voltage-controlled oscillator (VCO) (basic concepts), and VCO IC LM 566 - applications.

Phase Locked Loop

Operation, closed-loop analysis, lock and capture range, basic building blocks, PLL IC 565, applications of PLL.

MODULE 5 (6 hours)

Voltage Regulators

Fixed and adjustable voltage regulators, 78XX/79XX fixed voltage series regulators - connection of positive and negative voltage regulators - specifications, LM317 - adjustable voltage regulator, IC 723 - general purpose regulator - functional block diagram - low voltage and high voltage configurations, current boosting, current limiting, short circuit, and fold-back protection, limitations of IC 723, switching regulator (concept only).

Text Books

1. Roy D. C. and S. B. Jain, *Linear Integrated Circuits*, New Age International, 6th ed., 2021.
2. D.Franco S, *Design with Operational Amplifiers and Analog Integrated Circuits*, Tata McGraw Hill, Vol.1, 3rd ed., 2017.
3. Gayakwad R. A, *Op-Amps and Linear Integrated Circuits*, Pearson, 4th ed., 2015.
4. Botkar K. R., *Integrated Circuits*, Khanna Publishers, 10th ed., 2008
5. Robert L.Boylestad and Louis Nashelsky, *Electronic Devices and Circuit Theory*, Pearson Education India, 11th ed., 2015

Reference Books

1. C.G. Clayton, *Operational Amplifiers*, Butterworth & Company Publ. Ltd. Elsevier, 5th ed., 2003
2. David A. Bell, *Operational Amplifiers & Linear ICs*, Oxford University Press, 3rd ed., 2011
3. R.F. Coughlin & Fredrick Driscoll, *Operational Amplifiers & Linear Integrated Circuits*, PHI, 6th ed., 2000

4. Sedra A. S. and K. C. Smith, *Microelectronic Circuits*, Oxford University Press, 7th ed., 2014.
5. Thomas L Floyd, David M Buchla, *Fundamentals of Analog Circuits*, Pearson, 2nd ed., 2001.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: MOSFET and MOSFET Amplifier, TTL and CMOS Logic Families	8
1.1	MOSFET Structure - enhancement, and depletion types	1
1.2	Principle of operation, and characteristics	1
1.3	MOSFET as an amplifier	1
1.4	Biasing of discrete MOSFET amplifier	1
1.5	Small signal equivalent circuit	1
1.6	Small signal voltage and current gain, input and output impedance of CS configuration	1
1.7	Concepts of sourcing, sinking, fan-in, fan-out	1
1.8	Internal diagram of TTL NAND gate and CMOS NOR gate	1
	Module 2: Differential Amplifiers, Operational Amplifiers	8
2.1	Differential amplifier configurations using BJT - differential and common mode gains. Block Diagram of Op-Amp	1
2.2	Characteristics of Op-Amps - gain, bandwidth, slew rate, CMRR, offset voltage, offset current	1
2.3	Comparison of ideal and practical Op-Amp IC 741	1
2.4	Open-loop and closed-loop configurations	1
2.5	Applications of Op-Amps - Inverting amplifier	1
2.6	Non-inverting amplifier circuits, summing amplifier	1
2.7	Subtractor, integrator, differentiator	1
2.8	Practical integrator and differentiator circuits, comparator	1
	Module 3: Op-Amp Oscillators and Multivibrators, Active Filters	7
3.1	Phase shift and Wien-bridge oscillators	1
3.2	Triangular and sawtooth waveform generators	1
3.3	Astable multivibrators	1
3.4	Monostable multivibrators	1
3.5	Comparison with passive filters, first and second order low pass filters	1
3.6	High pass, band pass and band reject filters	1
3.7	Active filters, state variable filters	1
	Module 4: Timer and VCO, Phase Locked Loop	7

4.1	Timer IC 555 - functional diagram	1
4.2	Astable and monostable operations	1
4.3	Voltage-controlled oscillator (basic concepts)	1
4.4	VCO IC LM 566 - applications	1
4.5	PLL Operation, closed-loop analysis	1
4.6	Lock and capture range, basic building blocks	1
4.7	PLL IC 565, applications of PLL	1
	Module 5: Voltage Regulators	6
5.1	Fixed and adjustable voltage regulators	1
5.2	78XX/79XX fixed voltage series regulators - connection of positive and negative voltage regulators - specifications	1
5.3	LM317 - adjustable voltage regulator	1
5.4	IC 723 - general purpose regulator - functional block diagram	1
5.5	Current boosting, current limiting, short circuit, and fold-back protection, limitations of IC 723	1
5.6	Switching regulator (concept only)	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain enhancement type MOSFET.
2. Analyse small signal equivalent circuit of MOSFET amplifier.
3. Illustrate TTL NAND gate.

Course Outcome 2 (CO 2)

1. Explain the working of BJT differential amplifiers.
2. Limitations of Ideal Op-Amp Differentiator.
3. Problems based on closed-loop applications.

Course Outcome 3 (CO 3)

1. Explain the Wien-bridge oscillator.
2. Explain working of an Astable multivibrator.
3. Problems on monostable multivibrator.

Course Outcome 4 (CO 4)

1. What is the need of voltage controlled Oscillator?
2. Analyse the functional diagram of IC 555.
3. What is the function of low pass filter in PLL?

Course Outcome 5 (CO 5)

1. Outline the principle of fixed voltage regulators.
2. Draw the block diagram of IC 723.
3. Illustrate how a switching regulator differ from a linear regulator?

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: : B24EE2T04

Course Name: : ELECTRONIC CIRCUITS II

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Illustrate the construction of Enhancement MOSFET.
2. Explain the concept of fan-in and fan-out.
3. Illustrate the virtual ground concept in Op-Amp.
4. List any 6 characteristics of an ideal operational amplifier.
5. Explain the working principle of Wien-bridge oscillator.
6. Compare active and passive filters.
7. Draw the circuit of monostable multivibrator using IC 555.
8. What is the function of low pass filter in PLL?
9. Explain how current boosting is achieved using IC 723.
10. Derive the relation between line and phase values of voltage and current for delta connected system.

PART B

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

11. Draw the circuit of a common source amplifier using MOSFET. Derive the expressions for voltage gain and input resistance from small signal equivalent circuit. (14 marks)

OR

12. Explain the working of TTL NAND gate with the help of a neat diagram. (14 marks)

13. (a) Explain i) CMRR ii) Slew rate of an Op Amp. (4 marks)

- (b) Draw the circuit diagram and derive the voltage gain equation of Inverting amplifier. Design a Inverting amplifier with gain of 6. (10 marks)

OR

14. Develop a circuit diagram for practical integrator and draw its frequency response waveform. (14 marks)

15. Derive the equation for frequency of oscillation (f_o) of a Wein Bridge oscillator. Design a Wein Bridge oscillator for $f_o = 1$ kHz. (14 marks)

OR

16. Design a circuit to generate 1 kHz triangular wave with 5 V peak. (14 marks)

17. With the help of an internal functional diagram, explain the working of the monostable multivibrator using 555 timer. Derive the equation for pulse width. (14 marks)

OR

18. Explain the operation of Phase Locked Loop. What is lock range and capture range? (14 marks)

19. Explain how short circuit, fold back protection and current boosting are done using IC 723 voltage regulator. (14 marks)

OR

20. What are some common applications for the LM317? How the regulated output voltage of an LM317 can be set? (14 marks)

B24EE2L03	ELECTRICAL MEASUREMENTS LAB	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

The Electrical Measurements Lab is designed to equip students with the knowledge and skills to effectively use various measuring instruments and transducers for assessing physical parameters. The course is designed to build a solid foundation that empowers to analyse and comprehend the measurement of circuit parameters, magnetic quantities and calibration of various meters at different power factors. By successfully completing the course, students will gain the ability to bridge theoretical concepts with practical applications, enhancing their comprehension of electrical measurement principles.

Prerequisite

Introduction to Electrical Engineering, Electrical Measurements

Course Outcomes

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

CO 1	Determine power in single-phase and three-phase circuits using various methods. (Cognitive Knowledge Level: Apply)
CO 2	Analyse the magnetic properties of various electrical devices and evaluate energy consumption across different loads. (Cognitive Knowledge Level: Apply)
CO 3	Calibrate different meters using direct and phantom loading methods across various power factors in electrical systems. (Cognitive Knowledge Level: Apply)
CO 4	Evaluate electrical parameters using AC and DC bridges and to analyse the performance of electronic devices for an instrumentation system. (Cognitive Knowledge Level: Apply)
CO 5	Develop team management skills and prepare laboratory reports that logically and scientifically communicate experimental information. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Mark Distribution

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

Continuous Internal Evaluation Pattern

Attendance	10 marks
Continuous Assessment	15 marks
Performance	10 marks
Viva-Voce	5 marks
Lab Record	5 marks
Internal Exam	20 marks

End Semester Examination (ESE) Pattern:

The following guidelines should be followed regarding the award of marks

1. Preliminary work : 25 Marks
 - (a) Circuit Diagram: 15 Marks
 - (b) Theory and Procedure: 10 Marks
2. Implementing the work/Conducting the experiment : 30 Marks (usage of equipment and troubleshooting)
3. Result and Inference : 15 Marks
4. Viva Voce : 30 Marks

Students having a certified Lab Record are only eligible to appear for the End Semester Examination.

SYLLABUS

LIST OF EXPERIMENTS

1	Three phase power measurement using one wattmeter and two-wattmeter methods, and determination of active, reactive and apparent power drawn.
2	a) Extension of instrument range by using instrument transformers(CT and PT). b) Measurement of energy using TOD meter(R and RL load).
3	a) Determination of the B-H curve of a magnetic specimen. b) Familiarization of the fluxmeter. c) Verification of loading effect in ammeters and voltmeters with current measurement using clamp-on meter.
4	Calibration of 1-phase energy meter at various power factors using direct loading.
5	Calibration of 1-phase energy meter at various power factors using phantom loading.
6	Calibration of ammeter converted to voltmeter, using Slide-wire potentiometer.
7	Calibration of 3-phase, 4 wire energy meter using standard wattmeter.
8	Calibration of wattmeter using Crompton potentiometer.
9	a) Measurement of resistance using i) Wheatstone's bridge and ii) voltmeter-ammeter method. b) Measurement of capacitance using an AC bridge.
10	Calculate and verify the Z and Y parameters of a two-port network.
11	Plot the V-I characteristics of solar PV system.
12	Experimental evaluation of power quality analysis using power quality analyser.

Reference Books

1. H. Cotton, A. K. Sawhney, *A course in Electrical and Electronic Measurements & Instrumentation*, Dhanpat Rai, 19th ed., 2015.

2. J. B. Gupta, *A course in Electrical & Electronic Measurement & Instrumentation*, S. K. Kataria & Sons, 14th ed., 2014.
3. E. W. Golding, *Electrical Measurements and Measuring Instruments*, Pitman, 3rd ed., 2011.



B24EE2L04	DIGITAL ELECTRONICS LAB	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

The aim of this course is to equip the students with essential knowledge and practical skills in the design, analysis, and implementation of digital electronic systems. The course ensures the design and implementation of the combinational and sequential logic circuits, synchronous and asynchronous counters, and the concepts of a hardware description language VHDL. Students will gain the analytical and practical expertise to understand and design digital electronic systems for industry applications.

Prerequisite

Nil

Course Outcomes

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

CO 1	Understand and formulate digital functions using Boolean Algebra and minimize using K-map. (Cognitive Knowledge Level: Apply)
CO 2	Design and realize the combinational and sequential logic circuits. (Cognitive Knowledge Level: Apply)
CO 3	Design and implement the synchronous and asynchronous counters using flip-flops. (Cognitive Knowledge Level: Apply)
CO 4	Design and implementation of decimal decoders with display and implement simple circuits using a hardware description language VHDL. (Cognitive Knowledge Level: Apply)
CO 5	Develop the team management skills and prepare laboratory reports that logically and scientifically communicate experimental information. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Mark Distribution

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

Continuous Internal Evaluation Pattern

Attendance	10 marks
Continuous Assessment	15 marks
Performance	10 marks
Viva-Voce	5 marks
Lab Record	5 marks
Internal Exam	15 marks
Micro Project	5 marks

End Semester Examination (ESE) Pattern

The following guidelines should be followed regarding the award of marks

1. Preliminary work: 25 Marks
 - (a) Circuit Diagram: 15 Marks
 - (b) Theory and Procedure: 10 Marks
2. Implementing the work/Conducting the experiment: 30 Marks (usage of equipment and troubleshooting)
3. Result and Inference: 15 Marks
4. Viva Voce: 30 Marks

Micro Project: Students must complete a mandatory micro project in groups of up to four members. The project should involve the design and realization of a functional digital circuit along with a small hardware implementation. This project will be evaluated as part of the continuous internal evaluation, with a maximum of 5 marks. **Students having a certified Lab Record and Micro Project Report are only eligible to appear for the End Semester Examination.**

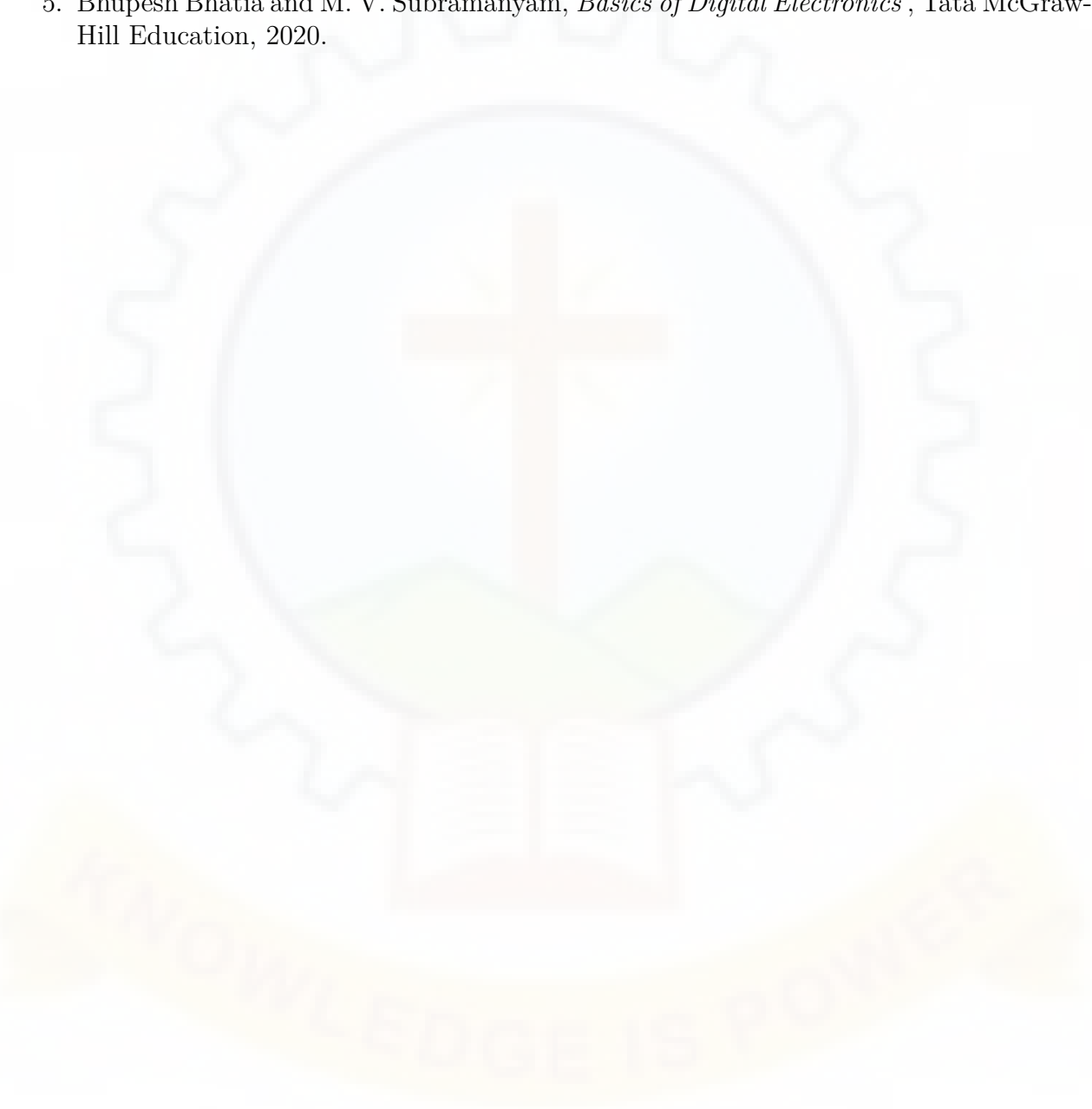
SYLLABUS

LIST OF EXPERIMENTS

1	a) Verification and realization of De Morgan's theorem. b) Realization of SOP and POS functions after K-map reduction.
2	Half adder and full adder realization using NAND gates.
3	4-bit adder/subtractor and BCD adder realization using IC 7483.
4	BCD to decimal decoder and BCD to 7-segment decoder realization.
5	Study of multiplexer IC and realization of combinational circuits using multiplexers.
6	Realization of SR, T, D and JK flip-flops using gates.
7	a) Study of flip-flop ICs (7474, 7476). b) Study of counter ICs (7490, 7493).
8	Realization of ripple up and down counters and modulo-N counters using flip-flops.
9	Design of synchronous up, down, and modulo-N counters.
10	Realization of 2-bit comparator using gates and study of 4-bit comparator IC 7485.
11	Realization of shift register counters, Ring counter and Johnson's counter.
12	a) Study of shift register IC 7495. b) Implementation of half adder and full adder using VHDL.

Reference Books

1. Floyd T. L., *Digital Fundamentals*, Pearson Education, 11th ed., 2017.
2. Salivahanan , *Digital Circuits and Design*, Oxford University Press, 6th ed., 2018.
3. A. Anand Kumar, *Fundamental of Digital Electronics* , Prentice Hall, 4th ed., 2016.
4. C. H. Roth and L. L. Kimney , *Fundamentals of Logic Design*, Cengage Learning, 7th ed., 2013.
5. Bhupesh Bhatia and M. V. Subramanyam, *Basics of Digital Electronics* , Tata McGraw-Hill Education, 2020.



B24MC2T04	UNIVERSAL HUMAN VALUES AND CONSTITUTIONAL RIGHTS	L	T	P	S	CREDIT	YEAR OF 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:

CO 1	Understand the importance of value education for holistic development and to fulfill human aspirations. (Cognitive Knowledge Level : Understand)
CO 2	Develop more awareness of themselves, and their surroundings (family, society, nature) to build harmonious and respectful relationships. (Cognitive Knowledge Level : Apply)
CO 3	Understand and appreciate the preamble and other features in the Indian Constitution to promote responsible citizenship. (Cognitive Knowledge Level : Understand)
CO 4	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

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

Assessment Pattern

Bloom's Category	Continuous Assessment	End Semester Examination (% 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) (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
	Total Hours	24 Hours
	Module 1: Introduction to Values	6
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
	Module 2: Harmony in the Human Being, Family and Society	5
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
	Module 3: Introduction to Constitution of India	5
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
	Module 4: State Policies and Fundamental Rights	8
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

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 CONSERVATION AND ENVIRONMENTAL SUSTAINABILITY	L	T	P	S	CREDIT	YEAR OF 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:

CO 1	Classify various energy resources and describe the importance of energy conservation. (Cognitive Knowledge Level: Understand)
CO 2	Explain the principles of renewable energy systems and their applications. (Cognitive Knowledge Level: Understand)
CO 3	Recognize major environmental impacts due to energy consumption and explain basic pollution control measures. (Cognitive Knowledge Level: Understand)
CO 4	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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
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 (% 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) (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
	Total Hours	24 Hours
	Module 1: Energy Resources and Conservation	6
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
	Module 2: Renewable Energy Technologies	6
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
	Module 3: Environmental Impact and Pollution Control	6
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
	Module 4: Sustainability and Green Practices	6
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.		

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)



MINOR

B24EEM31	CIRCUIT THEORY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course aims to equip students with a comprehensive understanding of circuit analysis, focusing on both time-domain and frequency-domain methods, as well as the application of Laplace transforms in solving complex electrical circuits. The course covers key topics such as DC and AC circuit analysis, coupled circuits, resonance, and two-port networks. Upon completion, students will be capable of analyzing and solving electrical circuits and applying network analysis methods to real-world electrical engineering problems.

Prerequisites

Basics of Electrical Engineering/Fundamentals of Electrical Engineering, Ordinary Differential Equations and Transforms.

Course Outcomes

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

CO 1	Apply the circuit theorems of electrical engineering to solve DC and AC circuits in steady-state. (Cognitive Knowledge Level: Apply)
CO 2	Solve electric circuits under various switching conditions to determine transient and steady-state behavior in the time domain. (Cognitive Knowledge Level: Apply)
CO 3	Apply and solve first and second-order DC and AC circuits using Laplace transforms, considering various initial conditions. (Cognitive Knowledge Level: Apply)
CO 4	Solve coupled circuits with sinusoidal excitation and analyze resonance in RLC circuits. (Cognitive Knowledge Level: Apply)
CO 5	Evaluate parameters of two-port networks and use transformations to solve network 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	3	2	1	1	2	1	1		1		2
CO 2	3	2	1	2	2	2	1		1		2
CO 3	3	2	1	2	2	2	1		1		2
CO 4	3	2	1	2		2	1		1		2
CO 5	3	2	1	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	10
Understand	40	40	40
Apply	40	40	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/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)

Circuit Theorems

DC and sinusoidal steady state analysis of circuits with dependent and independent sources applying superposition principle, source transformation, Thevenin's theorem, Norton's theorem, maximum power transfer theorems, and Reciprocity theorem.

MODULE 2 (9 hours)

Time Domain Analysis of First and Second-Order Circuits

Behaviour of R, L, C under switching conditions, time domain analysis of simple RL, RC, RLC series and parallel networks with excitation and initial conditions - Transient and steady-state response - time constant - underdamped, critically damped, overdamped and undamped RLC network

MODULE 3 (9 hours)

Circuit Analysis in the Frequency Domain

Review of Laplace transform. S-domain Analysis of Circuits - Solution of simple RL, RC, and RLC DC networks using Laplace Transforms, transformed equivalent of resistance, inductance, and capacitance - concept of the transformed circuit in s-domain.

AC circuit analysis in the frequency domain - Solution of RL, RC, and RLC circuits with sinusoidal excitation using Laplace Transforms, transformed circuits in s-domain.

MODULE 4 (9 hours)

Coupled Circuits

Conductively coupled circuits and mutual impedance - mutual inductance, dot polarity convention, coefficient of coupling - series and parallel coupled circuits, analysis of coupled circuits in s-domain.

Resonance in RLC Circuits

Resonance in series RLC circuits - impedance, phase angle, current, voltage, bandwidth, quality factor. Parallel resonance circuits (Concept only), resonant frequency for a tank circuit.

MODULE 5 (9 hours)

Two Port Networks

One-port network, two-port networks - Characterization in terms of impedance (Z), admittance (Y), hybrid (h) and transmission (T) parameters - conditions for symmetry and reciprocity of two-port networks, interconnection of two-port networks - series, parallel, and cascade, T- π representations, and transformation.

Text Books

1. Hayt W. H., Kemmerly J. E., and Durbin S. M., *Engineering Circuit Analysis*, Tata McGraw Hill, 10th ed., 2023.
2. K. S. Suresh Kumar, *Electric Circuit Analysis*, Pearson Publications, 2nd ed., 2020.
3. Alexander and Sadiku, *Fundamentals of Electric Circuits*, McGraw-Hill, 6th ed., 2021.
4. Allan H. Robbins, Wilhelm C. Miller, *Circuit Analysis: Theory and Practice*, Cengage Learning, 5th ed., 2016.

Reference Books

1. Joseph A. Edminister and Mahmood Nahvi, *Theory and Problems in Electric circuits*, McGraw Hill, 5th ed., 2010.
2. A. Sudhakar, Shyammohan S Palli, *Circuits and Networks*, McGraw Hill, 4th ed., 2019.
3. Van Valkenberg, *Network Analysis*, Prentice Hall India Learning Pvt. Ltd., 3rd ed., 2018.
4. Chakrabarti, *Circuit Theory Analysis and Synthesis*, Dhanpat Rai and Co., 7th ed., 2021.
5. R. Gupta, *Network Analysis and Synthesis*, S. Chand and Company Ltd, 2nd ed., 2020.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Circuit Theorems	9
1.1	Linearity and Superposition principle - Application to the analysis of DC and AC (sinusoidal excitation) circuits. Application of source transformation in electric circuit analysis	2
1.2	Thevenin's theorem - Application to the analysis of DC circuits	1
1.3	Thevenin's theorem - Application to the analysis of AC circuits	1
1.4	Norton's theorem - Application to the analysis of DC circuits	1
1.5	Norton's theorem - Application to the analysis of AC circuits	1
1.6	Maximum power transfer theorem - DC and AC steady state analysis with dependent and independent sources.	2
1.7	Reciprocity Theorem - Application to the analysis of DC and AC Circuits.	1
	Module 2: Time Domain Analysis of First and Second-Order Circuits	9
2.1	Behaviour of R, L, C under switching conditions	1
2.2	Time domain analysis of simple RL series and parallel networks with excitation and initial conditions	1
2.3	Time domain analysis of simple RC series and parallel networks with excitation and initial conditions	1
2.4	Time domain analysis of simple RLC series and parallel networks with excitation and initial conditions	2
2.5	Transient and steady-state response - time constant	1
2.6	Underdamped and critically damped RLC network	1
2.7	Overdamped and undamped RLC network	2
	Module 3: Circuit Analysis in the Frequency Domain	9
3.1	Review of Laplace transform	1
3.2	Solution of simple RL DC networks using Laplace transforms	1
3.3	Solution of simple RC DC networks using Laplace transforms	1
3.4	Solution of simple RLC DC networks using Laplace transforms	1
3.5	Transformed equivalent of resistance, inductance, and capacitance - concept of the transformed circuit in s-domain	1

3.6	Solution of RL circuits with sinusoidal excitation using Laplace transforms	1
3.7	Solution of RC circuits with sinusoidal excitation using Laplace transforms	1
3.8	Solution of RLC circuits with sinusoidal excitation using Laplace transforms	1
3.9	Transformed circuits in s-domain	1
	Module 4: Coupled Circuits, Resonance in RLC Circuits	9
4.1	Conductively coupled circuits and mutual Impedance	1
4.2	Mutual inductance, dot polarity convention	1
4.3	Coefficient of coupling - series and parallel coupled circuits	1
4.4	Analysis of coupled circuits in s-domain	2
4.5	Resonance in series RLC circuits - impedance, phase angle, current, voltage, bandwidth, quality factor	2
4.6	Parallel resonance circuits (Concept only), resonant frequency for a tank circuit	2
	Module 5: Two-port Networks	9
5.1	One-port network, two-port networks	1
5.2	Characterization in terms of impedance (Z) and admittance (Y) parameters	2
5.3	Characterization in terms of hybrid (h) and transmission (T) parameters	2
5.4	Conditions for symmetry and reciprocity of two-port networks	1
5.5	Interconnection of two-port networks series and parallel networks	1
5.6	Interconnection of two-port networks cascade networks	1
5.7	T- π representations and transformation	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. State and explain network theorems.
2. Problems on solving circuits using network theorems.
3. Apply source transformation to analyze a circuit.

Course Outcome 2 (CO 2)

1. Distinguish between the natural response and forced response.
2. Problems related to steady state and transient analysis of RL, RC, and RLC series circuits with DC excitation and initial conditions.
3. Problems related to steady state and transient analysis of RL, RC, and RLC series circuits with sinusoidal excitation.

Course Outcome 3 (CO 3)

1. Problems related to mesh analysis of transformed circuits in the s-domain.
2. Problems related to node analysis of transformed circuits in the s-domain.
3. Problems on transformed circuits in the s-domain.

Course Outcome 4 (CO 4)

1. Problems related to solutions of transformed circuits, including mutually coupled circuits in the s-domain.
2. Develop the impedance/admittance Vs frequency plot for the given RLC network.
3. Evaluate the parameters such as quality factor, bandwidth.

Course Outcome 5 (CO 5)

1. Problems to find Z, Y, h, and T parameters of simple two-port networks.
2. Derive the expression for Z parameters in terms of T parameters.
3. Show that the overall transmission parameter matrix for the cascaded two-port network is simply the matrix product of transmission parameters for each individual two-port network in cascade.

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg. No.:

Name:

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

THIRD SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: : B24EEM31

Course Name: : CIRCUIT THEORY

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. State and explain Norton's theorem.
2. Three resistors, $20\ \Omega$, $90\ \Omega$, and $10\ \Omega$, are star-connected. Obtain the equivalent delta circuit.
3. Develop s-domain equivalent circuit of an inductor having an initial current of I_0 .
4. Define Damping ratio. Draw the transient response of a second-order system for various values of the damping ratio.
5. A voltage of $v(t) = 10 \cos(1000t + 60^\circ)$ is applied to a series RLC circuit in which $R=10\ \Omega$, $L=0.02\ \text{H}$ and $C=10^{-4}\ \text{F}$. Find the steady current.
6. Find the transform representation in the s-domain of an inductor with initial current and the transform representation in the s-domain of a capacitor with initial voltage.
7. Compare series and parallel resonance on the basis of resonant frequency, impedance, and bandwidth.
8. Two inductively coupled coils have self inductances $L_1 = 50\ \text{mH}$ and $L_2 = 200\ \text{mH}$. If the coefficient of coupling is 0.5 (a), find the value of mutual inductance between the coils, and (b) what is the maximum possible mutual inductance?
9. What are the conditions for reciprocity of a two-port network in terms of Z parameters? What are the similar conditions in terms of y parameters?

10. How do we find equivalent T network of a two port network if z parameters are given?

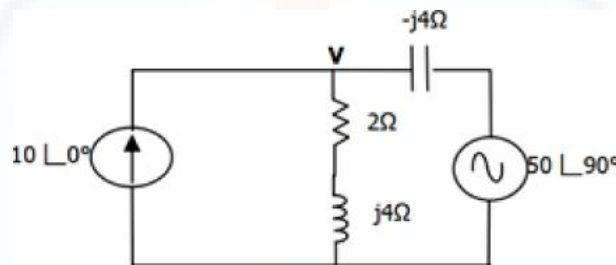
PART B

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

11. (a) State and explain the Reciprocity theorem with an example. (6 marks)
(b) State and prove the maximum power transfer theorem. (8 marks)

OR

12. (a) Use the superposition theorem to find the voltage V shown in the figure. (8 marks)



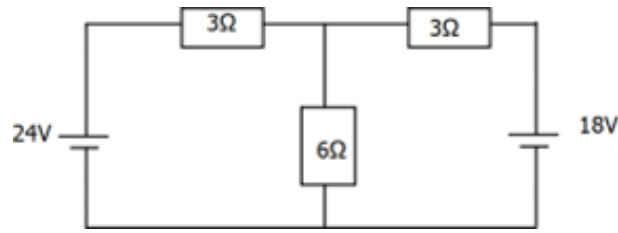
- (b) State Thevenin's theorem. How is Thevenin equivalent circuit developed? (6 marks)
13. Derive the dynamic equations for analyzing the behavior of step response of a series RLC circuit. (14 marks)

OR

14. A capacitor C having capacitance of 0.2 F is initially charged to 10 volts and it is connected to an RL series circuit comprising of $R=4\Omega$ and $L = 1$ H, by means of a switch at time $t=0$. Find the current through the circuit by means of Laplace transformation method. (14 marks)
15. (a) An LC network comprises of series inductor branches L_1 and L_2 each of inductance 2 H and parallel capacitor branches C_1 and C_2 each with capacitance 1 F. Find the transform impedance $Z(s)$. (6 marks)
(b) What are reciprocal networks? What are the conditions that should be satisfied by a network to be reciprocal? (8 marks)

OR

16. (a) How is transfer function representation of a network function helpful in analyzing the behavior of the network? Mention the significance of poles and zeros in network functions? (8 marks)



- (b) Using Laplace transformation, find the current in the $6\ \Omega$ resistor. (6 marks)
17. (a) In a series RLC circuit, for frequencies more than the resonant frequency, what nature of reactance is exhibited? Substantiate the reason for the answer. (6 marks)
- (b) A series RLC circuit consists of $R = 25\ \Omega$, $L = 0.01\ \text{H}$, $C = 0.04\ \mu\text{F}$. Calculate the resonant frequency. If $10\ \text{V}$ is applied to the circuit at resonant frequency, calculate the voltages across L and C . Find the frequencies at which these voltages are maximum. (8 marks)

OR

18. (a) A coil of resistance $20\ \Omega$ and inductance of $200\ \text{mH}$ is connected in parallel with a variable capacitor. This combination is connected in series with a resistance of $8000\ \Omega$. Supply voltage is $200\ \text{V}$, $50\ \text{Hz}$. Calculate The value of C at resonance, The Q of the coil, Dynamic resistance of the circuit. (7 marks)
- (b) Derive expressions for selectivity and bandwidth of a parallel tuned circuit. (7 marks)
19. A two-port network has the following z parameters: $z_{11} = 10\ \Omega$, $z_{12} = z_{21} = 5\ \Omega$, $z_{22} = 12\ \Omega$. Evaluate the y parameters for the network. (14 marks)

OR

20. A symmetrical T-network has the following open-circuit and short-circuit impedances: $Z_{oc} = 800\ \Omega$ (open circuit impedance) $Z_{sc} = 600\ \Omega$ (short circuit impedance). Calculate impedance values of the network. (14 marks)

B24EEM32	ELECTRIC CIRCUITS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course aims to equip students with a comprehensive understanding of circuit analysis, focusing on both time-domain and frequency-domain methods, as well as the application of Laplace transforms in solving complex electrical circuits. The course covers key topics such as DC and AC circuit analysis, three-phase systems, and two-port networks. Upon completion, students will be capable of analyzing and solving electrical circuits and applying network analysis methods to real-world electrical engineering problems.

Prerequisites

Basics of Electrical Engineering/Fundamentals of Electrical Engineering, Ordinary Differential Equations and Transforms.

Course Outcomes

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

CO 1	Apply the circuit theorems of electrical engineering to solve DC circuits in steady-state. (Cognitive Knowledge Level: Apply)
CO 2	Solve electric circuits under various switching conditions to determine transient and steady-state behavior in the time domain. (Cognitive Knowledge Level: Apply)
CO 3	Apply and solve first and second-order DC and AC circuits using Laplace transforms, considering various initial conditions. (Cognitive Knowledge Level: Apply)
CO 4	Analyze balanced and unbalanced 3-phase star-connected and delta-connected systems. (Cognitive Knowledge Level: Apply)
CO 5	Evaluate parameters of two-port networks and use transformations to solve network 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	3	3	2	1	1						1
CO 2	3	3	1	2	1						1
CO 3	3	3	1	2	1						1
CO 4	3	3	1	2	1						1
CO 5	3	3	1	2	1						1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	20	20	10
Understand	40	40	40
Apply	40	40	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/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)

DC Circuit Analysis and Theorems

Review of mesh analysis. Nodal voltage analysis of circuits containing resistors and independent sources. Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum Power Transfer theorem, and Reciprocity theorem (with independent sources only).

MODULE 2 (9 hours)

Time Domain Analysis of First and Second-Order Circuits

Behaviour of R, L, C under switching conditions, time domain analysis of simple RL, RC, RLC series and parallel networks with excitation and initial conditions - Transient and steady-state response - time constant - underdamped, critically damped, overdamped and undamped RLC network

MODULE 3 (9 hours)

Circuit Analysis in the Frequency Domain

Review of Laplace transform. S-domain Analysis of Circuits - Solution of simple RL, RC, and RLC DC networks using Laplace Transforms, transformed equivalent of resistance, inductance, and capacitance - concept of the transformed circuit in s-domain.

AC circuit analysis in the frequency domain - Solution of RL, RC, and RLC circuits with sinusoidal excitation using Laplace Transforms, transformed circuits in s-domain.

MODULE 4 (9 hours)

Three-phase Networks

Three phase power in sinusoidal steady state-complex power, apparent power and power triangle. Steady state analysis of three-phase, three-wire and four-wire balanced and unbalanced Y circuits, Balanced and unbalanced Δ circuit. Three phase power measurement and two-wattmeter method.

MODULE 5 (9 hours)

Two Port Networks

One-port network, two-port networks - Characterization in terms of impedance (Z), admittance (Y), hybrid (h) and transmission (T) parameters - conditions for symmetry and reciprocity of two-port networks, interconnection of two-port networks - series, parallel, and cascade, T- representations and transformation.

Text Books

1. Hayt W. H., Kemmerly J. E., and Durbin S. M., *Engineering Circuit Analysis*, Tata McGraw Hill, 10th ed., 2023.
2. K. S. Suresh Kumar, *Electric Circuit Analysis*, Pearson Publications, 2nd ed., 2020.
3. Alexander and Sadiku, *Fundamentals of Electric Circuits*, McGraw-Hill, 6th ed., 2021.
4. Allan H. Robbins, Wilhelm C. Miller, *Circuit Analysis: Theory and Practice*, Cengage Learning, 5th ed., 2016.

Reference Books

1. Joseph A. Edminister and Mahmood Nahvi, *Theory and Problems in Electric circuits*, McGraw Hill, 5th ed., 2010.
2. A. Sudhakar, Shyammoan S Palli, *Circuits and Networks*, McGraw Hill, 4th ed., 2019.
3. Van Valkenberg, *Network Analysis*, Prentice Hall India Learning Pvt. Ltd., 3rd ed., 2018.
4. Chakrabarti, *Circuit Theory Analysis and Synthesis*, Dhanpat Rai and Co., 7th ed., 2021.
5. R. Gupta, *Network Analysis and Synthesis*, S. Chand and Company Ltd, 2nd ed., 2020.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: DC Circuit Analysis and Theorems	9
1.1	Review of mesh analysis	1
1.2	Nodal voltage analysis of circuits containing resistors and independent sources	2
1.3	Superposition theorem - application to the analysis of DC circuit with independent sources	2
1.4	Thevenin's theorem, Norton's theorem - application to the analysis of DC circuits with independent sources.	2
1.5	Maximum Power Transfer theorem, and Reciprocity theorem - application to the analysis of DC circuits with independent sources	2
	Module 2: Time Domain Analysis of First and Second-Order Circuits	9
2.1	Behaviour of R, L, C under switching conditions	1
2.2	Time domain analysis of simple RL series and parallel networks with excitation and initial conditions	1
2.3	Time domain analysis of simple RC series and parallel networks with excitation and initial conditions	1
2.4	Time domain analysis of simple RLC series and parallel networks with excitation and initial conditions	2
2.5	Transient and steady-state response - time constant	1
2.6	Underdamped and critically damped RLC network	1
2.7	Overdamped and undamped RLC network	2
	Module 3: Circuit Analysis in the Frequency Domain	9
3.1	Review of Laplace transform	1
3.2	Solution of simple RL DC networks using Laplace transforms	1
3.3	Solution of simple RC DC networks using Laplace transforms	1
3.4	Solution of simple RLC DC networks using Laplace transforms	1
3.5	Transformed equivalent of resistance, inductance, and capacitance - concept of the transformed circuit in s-domain	1
3.6	Solution of RL circuits with sinusoidal excitation using Laplace transforms	1
3.7	Solution of RC circuits with sinusoidal excitation using Laplace transforms	1
3.8	Solution of RLC circuits with sinusoidal excitation using Laplace transforms	1
3.9	Transformed circuits in s-domain	1
	Module 4: Three-phase Networks	9

4.1	Three phase power in sinusoidal steady state-complex power, apparent power and power triangle.	2
4.2	Steady state analysis of three-phase three-wire and four-wire balanced and unbalanced Y circuits	3
4.3	Steady state analysis of three-phase three-wire and four-wire Balanced and unbalanced Delta circuit.	2
4.4	Three phase power measurement and two-wattmeter method.	2
	Module 5: Two-port Networks	9
5.1	One-port network, two-port networks	1
5.2	Characterization in terms of impedance (Z) and admittance (Y) parameters	2
5.3	Characterization in terms of hybrid (h) and transmission (T) parameters	2
5.4	Conditions for symmetry and reciprocity of two-port networks	1
5.5	Interconnection of two-port networks series and parallel networks	1
5.6	Interconnection of two-port networks cascade networks	1
5.7	T- π representations and transformation	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. State and explain the network theorems.
2. Problems on solving circuits using network theorems.

Course Outcome 2 (CO 2)

1. Difference between under-damped, critically damped, and over-damped RLC circuits.
2. Problems on time domain analysis of RL, RC, and RLC series and parallel circuits.

Course Outcome 3 (CO 3)

1. Distinguish between the natural response and forced response.
2. Problems on steady state and transient analysis of RL, RC, and RLC series circuits with DC and sinusoidal excitation.

Course Outcome 4 (CO 4)

1. Problems on the analysis of balanced star and delta configurations.
2. Problems on analysis of unbalanced star and delta configurations.

Course Outcome 5 (CO 5)

1. Problems on finding Z and Y parameters of simple two-port networks.
2. Problems on finding h parameters and transmission parameters in two-port networks.



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: B24EEM32

Course Name: ELECTRIC CIRCUITS

Max. Marks: 100

Duration: 3 hours

PART A

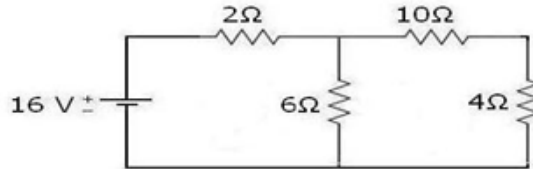
Answer all questions. Each question carries 3 marks.

1. Compare the analogy between the Nodal and Mesh analysis methods.
2. State and explain the superposition theorem with suitable examples
3. Differentiate between under-damped and over-damped RLC network.
4. Differentiate between transient and steady state analysis.
5. Explain the initial value and final value theorem.
6. How do you transform sources in the s-domain?
7. Define the terms, real power, reactive power, star-connected three-phase, and apparent power.
8. Draw the circuit of a four-wire star connected three phase circuit and mark the line and phase voltage.
9. Explain the condition for symmetry and reciprocity with respect to Z-parameters.
10. Draw the equivalent circuit representation in terms of h-parameters.

PART B

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

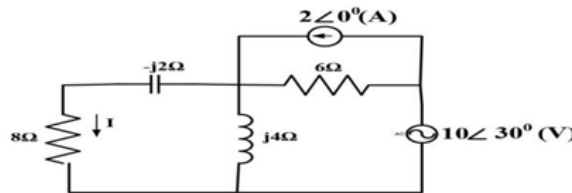
11. (a) Draw the Thevenin's equivalent circuit and hence find the power dissipated across R_L . (10 marks)



- (b) Compare the difference between dependent and independent sources. (4 marks)

OR

12. (a) Determine the power dissipated across 8Ω for the circuit shown by applying the Superposition theorem. (10 marks)



- (b) State and explain Maximum power transfer theorem. (4 marks)
13. (a) An RLC circuit consists of a resistor $R=20\Omega$, $L=0.5\text{H}$ and a capacitor $C=0.1\text{F}$. A step voltage of 10V is applied at $t=0$. Find the natural response of the circuit, including the characteristic equation, roots, and general solution. (9 marks)
- (b) Derive the expression for the time constant of an RL circuit. (5 marks)

OR

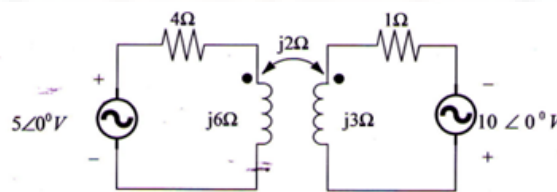
14. (a) An RC circuit consists of a resistor $R=10\Omega$ and $C=1\text{F}$. If a step voltage of 5V is applied at $t=0$, find the energy stored in the capacitor at $t=0.5\text{s}$. (7 marks)
- (b) Explain the role of damping in RLC circuits. (7 marks)
15. (a) The current through 5Ω resistor is $I(s) = (5s+3)/(s^2+5s+6)$. Find the power dissipated across the 5Ω resistor. (7 marks)
- (b) Derive the equation for the transient current flow through a series RL circuit with a DC source and zero initial condition in the s-domain. (7 marks)

OR

16. (a) Derive the equation for the transient current flow through series RC circuit with DC source and zero initial condition in s-domain. (7 marks)
- (b) Explain the term time constant with respect to series RL circuit with suitable figures. (7 marks)
17. (a) Explain two watt-meter method to measure the three phase power with the help of suitable equations. (7 marks)
- (b) Derive the relationship between the line and phase voltage in a three-phase star-connected circuit. (7 marks)

OR

18. (a) A three-phase, three-wire, balanced, delta-connected load yields wattmeter readings of 154 W and 557 W. Obtain the load impedance if the line voltage is 141.4 V. (7 marks)
- (b) Derive the relationship between the line and phase current of a three-phase delta-connected circuit (7 marks)
19. (a) Derive the relationship between h and transmission parameters. (6 marks)
- (b) Find the Z-parameters of the two-port circuit. (8 marks)



OR

20. (a) Explain Y parameters with its equivalent circuit representation. (10 marks)
- (b) Differentiate driving point and transfer functions with respect to a two-port network. (4 marks)

B24EEM33	INTRODUCTION TO POWER ENGINEERING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course aims to give students a comprehensive understanding of power generation, transmission, and distribution systems, focusing on various conventional and modern technologies. It provides an overview of key topics such as hydroelectric, steam, diesel, gas turbine, and nuclear power plants, the economics of power generation, transmission system design, AC and DC distribution systems, and the introduction to smart grids. Upon successful completion, students will gain a solid foundation in power generation technologies, electrical transmission, distribution systems, and smart grid concepts, equipping them with the skills to analyse, design, and optimize electrical power systems efficiently.

Prerequisites

Basics of Electrical Engineering/Fundamentals of Electrical Engineering

Course Outcomes

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

CO 1	Understand the various conventional sources of energy generation. (Cognitive Knowledge Level: Understand)
CO 2	Understand the economics of power generation and power factor improvement. (Cognitive Knowledge Level: Understand)
CO 3	Design mechanical parameters of a transmission system. (Cognitive Knowledge Level: Apply)
CO 4	Design electrical parameters of a transmission system. (Cognitive Knowledge Level: Apply)
CO 5	Classify and analyse different types of AC and DC distribution systems and smart grid concepts. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	1	2	1		2	1				1
CO 2	3	1	2	1		2	1			1	1
CO 3	3	1	1	1		1	1				1
CO 4	3	1	1	1		1	1				1
CO 5	3	2	2	1		2	1			1	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/Quiz/Course Project	10 marks
Self Study	5 marks

End Semester Examination Pattern

noindent 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)

Generation of Power

Conventional sources: Hydroelectric power plants - selection of site. General arrangement of the hydel plant, components of the plant, classification of the hydel plants. Water turbines - Pelton wheel, Francis, Kaplan, and propeller turbines, small hydro generation.

Steam power plants - Working of steam plant, power plant equipment, and layout, steam turbines.

Diesel power plant - Elements of diesel power plant, applications.

Gas Turbine Power Plant - Introduction merits and demerits, selection site, fuels for gas turbines, general arrangement of simple gas turbine power plant, comparison of gas power plant with steam power plants.

Nuclear Power Plants - Nuclear reaction, nuclear fission process, nuclear plant layout, classification of reactors.

MODULE 2 (8 hours)

Economics of Power Generation

Types of loads, load curve, terms and factors, peak load and base load, cost of electrical energy, numerical problems.

Power factor improvement - causes of low power factor, disadvantages, methods of power factor improvement, calculations of power factor correction, economics of power factor improvement.

MODULE 3 (10 hours)

Transmission System

Different types of transmission systems - High voltage transmission - advantages.

Mechanical design of overhead transmission line: Main components of overhead lines, types of conductors, line supports.

Insulators - types, string efficiency, methods of improving string efficiency, numerical problems.

Corona - Critical disruptive voltage, visual critical voltage, corona loss, factors affecting corona, advantages and disadvantages, methods of reducing corona - numerical problems (Derivations not required).

Sag and tension - calculation - supports are at equal levels - effect of ice and wind loading - numerical problems (Derivations not required).

MODULE 4 (9 hours)

Electrical Design of Transmission Line

Constants of transmission line – Resistance, inductance, and capacitance.

Inductance of a single-phase transmission line, capacitance of a single-phase transmission line, inductance of a three-phase transmission line, capacitance of a three-phase transmission line - numerical Problems (For symmetrical and transposed lines, Effect of earth neglected, numerical problems, Derivations not required).

MODULE 5 (9 hours)

Distribution Systems and Smart Grid

Introduction to distribution system - Types, Feeder, Distributor, Service mains.

Types of DC distributors - distributor fed at one end and at both ends - concentrated loading only, numerical problems.

Types of AC distributors - power factor referred to sending end voltage - power factor referred to respective load voltage - numerical problems.

Smart Grid - Introduction - challenges and benefits, architecture of smart grid.

Text Books

1. D. P. Kothari and I. Nagrath, *Power System Engineering*, Tata McGraw Hill, 3rd ed., 2019.
2. C. L. Wadhwa, *Electrical Power system*, New Age International Publishers, 7th ed., 2017.
3. V. K. Mehta, Rohith Mehta, *Principles of Power System*, S. Chand and Company Ltd, 4th revised ed., 2022.
4. Gupta J. B., *Transmission and Distribution of Electrical Power*, S. K. Kataria and Sons, 2009.

Reference Books

1. A. Chakrabarti, M. L. Soni, P. V. Gupta, V. S. Bhatnagar, *A text book of Power system Engineering*, Dhanpat Rai, 2000
2. Grainer J. J, Stevenson W. D., *Power system Analysis*, McGraw Hill Education, 1st ed., 2017.
3. Stuart Borlase, *Smart Grids, Infrastructure, Technology and Solutions*, CRC Press, 2013.
4. S. Pabla, *Electric Power Distribution*, 7th ed., Tata McGraw Hill Publication, 2019.
5. Uppal S. L. and S. Rao, *Electrical Power Systems*, Khanna Publishers, 19th reprint, 2024.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Conventional Energy Sources	9
1.1	Introduction and history of power generation	1
1.2	Hydel power plant - schematic, components	1
1.3	Hydel power plant - turbines	1
1.4	Steam power plant - schematic, components	1
1.5	Steam power plant - turbines	1
1.6	Diesel power plant: Elements of diesel power plant, applications	1
1.7	Gas Turbine Power Plant: Introduction, merits and demerits, selection site, fuels for gas turbines	1
1.8	General arrangement of simple gas turbine power plant, comparison of gas power plant with steam power plants	1
1.9	Nuclear power generation - Nuclear reaction, nuclear fission process, nuclear plant layout, classification of reactors	1
	Module 2: Economics of Power Generation and Power Factor Improvement	8
2.1	Introduction - Important terms associated with power generation such as maximum demand, load factor	1
2.2	Numerical problems on the economics of generation	1
2.3	Load curve and load duration curve	1
2.4	Problems on load curve and load duration curve	1
2.5	Significance of power factor in power system, methods of power factor improvement	1
2.6	Numerical problems on capacitor value evaluation and power factor improvement	1
2.7	Economics of power factor improvement	1
2.8	Numerical problems	1
	Module 3: Transmission System	10
3.1	Different types of transmission system - High voltage transmission – advantages	1
3.2	Mechanical design of overhead transmission line: Main components of overhead lines – types of conductors, line supports	1
3.3	Insulators - Types, String efficiency	1
3.4	Methods of improving string efficiency	1
3.5	Numerical problems	1
3.6	Corona – Critical disruptive voltage, visual critical voltage, corona loss (Derivations not required)	1
3.7	Factors affecting corona, advantages and disadvantages, methods of reducing corona	1

3.8	Numerical problems	1
3.9	Sag and tension - calculation - supports are at equal levels - effect of ice and wind loading	1
3.10	Numerical problems	1
	Module 4: Electrical Parameters of a Transmission Line	9
4.1	Constants of transmission line – Resistance, inductance, and capacitance, skin effect, proximity effect	1
4.2	Inductance of a single-phase transmission line	1
4.3	Numerical problems	1
4.4	Capacitance of a single phase transmission line (Effect of earth neglected)	1
4.5	Numerical problems	1
4.6	Inductance of a three-phase transmission line with symmetrical spacing, transposition of lines (Derivations not required)	1
4.7	Numerical problems	1
4.8	Capacitance of a three-phase transmission line with symmetrical spacing- transposition of lines (Derivations not required)	1
4.9	Numerical problems	1
	Module 5: Distribution Systems and Smart Grid	9
5.1	Introduction to distribution system - Types	1
5.2	Feeder, Distributor, Service mains	1
5.3	DC distribution system - various types, distributor fed at one end	1
5.4	Distributor fed at both ends	1
5.5	Numerical problems on DC distributor	1
5.6	AC distribution system various types - power factor referred to sending end voltage	1
5.7	Power factor referred to respective load voltages	1
5.8	Numerical problems	1
5.9	Smart grid - Introduction - challenges and benefits - architecture of smart grid	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Schematic and equipment of Conventional Power generation schemes.
2. Comparison of various turbines associated with conventional generation.
3. What are the methods employed for improving efficiency of thermal power plant?

Course Outcome 2 (CO 2)

1. Definition and Calculation of various terms associated with power generation.
2. Problems on the economics of power generation and power factor improvement.
3. Methods of improving power factor.

Course Outcome 3 (CO 3)

1. Mechanical design of transmission lines.
2. Problems of corona, sag, and insulators.
3. What are the critical voltages in the formation of Corona? What is the effect of Corona?

Course Outcome 4 (CO 4)

1. Problems on inductance of transmission lines.
2. Problems on capacitance of transmission lines.
3. Definition on transposition of line and changes in electrical parameters.

Course Outcome 5 (CO 5)

1. Problems on DC distribution systems.
2. Problems on AC distribution systems.
3. Architecture and technologies in smart grid.

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg. No.:

Name:

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

FIRST SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: B24EEM33

Course Name: INTRODUCTION TO POWER ENGINEERING

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Illustrate the environmental factors affecting hydel energy generation.
2. How are turbines classified? How is a turbine selected for a site?
3. Explain the significance of load factor and load curve.
4. Discuss the disadvantages of low power factor in power system.
5. What is corona? Explain the factors have an influence on corona loss.
6. Describe the merits of high voltage transmission.
7. Illustrate skin effect in transmission line.
8. Explain transposition of lines. Comment on its necessity in the system.
9. Discuss the requirements of a distribution system.
10. Distinguish between feeder, distributor, and service mains.

PART B

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

11. (a) Explain the general arrangement of gas turbine power plant. (8 marks)
(b) Describe the importance of small hydro power generation along with their advantages and disadvantages. (6 marks)

OR

12. (a) With the help of a block diagram, illustrate the working of a nuclear power plant. (14 marks)

13. A generating station has the following daily load cycle:

Time (Hours)	0-6	6-10	10-12	12-16	16-20	20-24
Load (MW)	40	50	60	50	70	40

Draw the load curve and calculate (i) Units generated per day (ii) Average load and (iii) load factor. (14 marks)

OR

14. Illustrate the various methods of power factor improvement with suitable sketches. (14 marks)
15. (a) Derive the equation for Sag in transmission lines, when the support is at equal heights. (8 marks)
(b) Discuss the difference between disruptive critical corona and visual critical corona. (6 marks)

OR

16. (a) In a 33 kV overhead line, there are three units in the string of insulators. If the capacitance between each insulator pin and earth is 11% of the self-capacitance of each insulator, find (i) the distribution of voltage over 3 insulators and (ii) string efficiency. (9 marks)
(b) Illustrate various types of conductors used in power system. (5 marks)
17. (a) A 3-phase 70 km long transmission line has its conductors of 1 cm diameter spaced at the corners of the equilateral triangle of 100 cm side. Find the inductance per phase of the system. (6 marks)
(b) Derive capacitance of a single-phase two wire transmission line. (8 marks)

OR

18. (a) The three conductors of a 3-phase line are arranged at the corners of a triangle of sides 2 m, 2.5 m, and 4.5 m. Calculate the inductance per km of the line when the conductors are regularly transposed. The diameter of each conductor is 1.24 cm. (6 marks)

- (b) A single-phase transmission line has two parallel conductors 3 m apart, radius of each conductor being 1 cm. Calculate the capacitance of the line per km. (8 marks)

19. (a) Compare radial and ring main distribution system with the help of appropriate schematics. (6 marks)
- (b) A two conductor main, AB, 500 m in length is fed from both ends at 250 V. Loads of 50 A, 60 A, 40 A and 30 A are tapped at distances of 100 m, 250 m, 350 m and 400 m from end A respectively. If the cross section of conductor is 1 cm^2 and specific resistance of material is $1.7 \mu\Omega \text{ cm}$, determine the minimum consumer voltage. (8 marks)

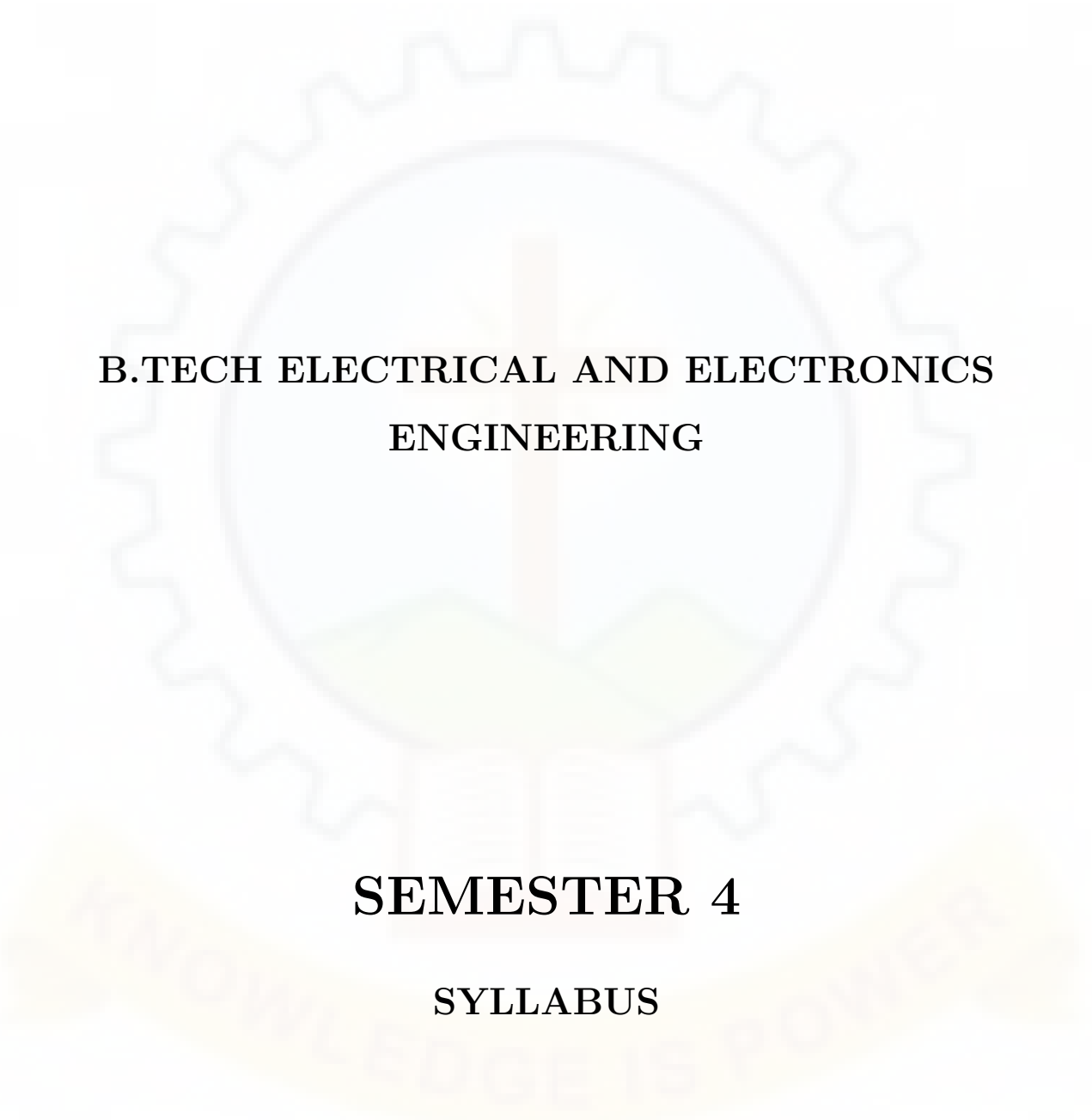
OR

20. (a) A single-phase distributor one km long has resistance and reactance per conductor of 0.1Ω and 0.15Ω respectively. At the far end, the voltage $V_B = 200 \text{ V}$ and the current is 100 A at a pf of 0.8 lagging. At the mid-point M of the distributor, a current of 100 A is tapped at a pf of 0.6 lagging with reference to the voltage V_M at the mid-point. Calculate (i) voltage at mid-point (ii) sending end voltage V_A (iii) phase angle between V_A and V_B (9 marks)
- (b) Outline the architecture of smart grid. (5 marks)

MAR ATHANASIOUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution

Kothamangalam, Kerala, India



**B.TECH ELECTRICAL AND ELECTRONICS
ENGINEERING**

SEMESTER 4

SYLLABUS

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	B24EE2T05	SIGNALS AND SYSTEMS	2-2-0-5	4	3
C	B24EE2T06	POWER ELECTRONICS	3-1-0-5	4	4
D	B24EE2T07	ELECTROMAGNETIC THEORY	2-1-0-4	3	3
E	B24HU2T01	BUSINESS ECONOMICS AND FINANCIAL MANAGEMENT	3-0-0-4	3	3
F	B24EE2T08	MICROPROCESSORS AND MICROCONTROLLERS	2-2-0-5	4	4
G	B24EE2L05	ELECTRICAL MACHINES LAB I	0-0-3-2	3	2
H	B24EE2L06	ELECTRONIC CIRCUITS LAB II	0-0-3-2	3	2
M	B24EEM4X	MINOR	3-1-0-5	4	4
N	B24EEH4X	HONOURS	2-2-0-5	4	4
TOTAL				36	25

MINOR

COURSE NO.	COURSES
BASKET 1	
B24EEM41	LINEAR CONTROL SYSTEMS
BASKET 2	
B24EEM42	FUNDAMENTALS OF ELECTRICAL MACHINES
BASKET 3	
B24EEM43	ENERGY STORAGE SYSTEMS

HONOURS

COURSE NO.	COURSES
BASKET 1	
B24EEH41	NETWORK ANALYSIS AND SYNTHESIS
BASKET 2	
B24EEH41	NETWORK ANALYSIS AND SYNTHESIS
BASKET 3	
B24EEH41	NETWORK ANALYSIS AND SYNTHESIS

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:

CO 1	Apply the concept, properties and important models of discrete random variables and, using them, analyse suitable random phenomena and model variables in engineering systems. (Cognitive Knowledge Level: Apply)
CO 2	Apply the concept, properties and important models of continuous random variables and, using them, analyse suitable random phenomena. (Cognitive Knowledge Level: Apply)
CO 3	Apply bivariate probability distributions to model complex systems and examine stochastic processes using autocorrelation, power spectrum. (Cognitive Knowledge Level: Apply)
CO 4	Apply numerical techniques for root-finding, interpolation, and integration, and evaluate round-off, truncation, and relative computational errors. (Cognitive Knowledge Level: Apply)
CO 5	Apply standard numerical techniques for solving systems of equations, fitting curves on given numerical data and solving ordinary differential equations. (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	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 (% 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/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.

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).

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.

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).

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 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)
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
	Total Hours	45 Hours
1	Module 1: Univariate Discrete Probability Distributions	8
1.1	Discrete probability distributions	4
1.2	Binomial distribution - mean, variance, Poisson distribution - mean, variance, Poisson approximation to binomial	4
2	Module 2: Univariate Continuous Probability Distributions	8
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
3	Module 3: Stochastic Processes	11
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
4	Module 4: Numerical Methods-I	9
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
5	Module 5: Numerical Methods - II	9
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

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 a 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, ω, ϕ are independent variables. Assume that A has mean 3 and a variance of 9, ϕ is uniformly distributed between $-\pi$ and π , and ω 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)

B24EE2T05	SIGNALS AND SYSTEMS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	2	0	5	3	2024

Preamble

This course provides a comprehensive introduction to signals and systems, covering their classification, properties, and mathematical modeling. It explores frequency-domain analysis using Fourier and Laplace transforms, system modeling techniques, and discrete-time system characterization with Z-transforms. This course enhances the understanding of signals and systems, preparing students for careers in communication, control, and signal processing.

Prerequisites

Circuits and Networks.

Course Outcomes

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

CO 1	Understand the fundamental concepts of signals, their classifications, and basic operations on continuous-time and discrete-time signals. (Cognitive Knowledge Level: Understand)
CO 2	Analyze continuous time signals in the frequency domain using Fourier series and Fourier transforms, and interpret spectral properties. (Cognitive Knowledge Level: Apply)
CO 3	Model continuous-time LTI systems using differential equations, Laplace transforms, and block diagrams. (Cognitive Knowledge Level: Apply)
CO 4	Understand the process of sampling, and analyze discrete-time signals in the frequency domain. (Cognitive Knowledge Level: Apply)
CO 5	Model discrete-time LTI systems using difference equations, Z-transforms, and block diagrams. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	2	2	2	1	1				1
CO 2	3	3	2	2	2	1	1				1
CO 3	3	3	2	2		1	1				1
CO 4	3	3	2	2	1	1	1				1
CO 5	3	3	2	2	2	1	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/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 (10 hours)

Introduction to Signals and Systems

Concept of signals - continuous and discrete-time signals - practical examples, elementary signals, classification of signals, basic operations on signals.

Concept of system - classification of systems, properties of systems - time invariance - linearity - causality - memory - stability, practical examples of LTI systems - electrical, mechanical, and thermal systems, step response, impulse response - convolution integral and convolution sum.

Use simulation software like MATLAB/Scilab to demonstrate elementary signals and its operations (Tutorial/Assignment only).

MODULE 2 (9 hours)

Frequency Domain Characterization of Continuous-time Signals and Systems

Fourier series - existence, harmonic analysis of common signals.

Fourier transform - existence, Fourier transform of common signals, properties of Fourier transform, energy spectral density, and power spectral density, concept of frequency response – magnitude response and phase response.

Use simulation software like MATLAB/Scilab to obtain Fourier Series/Transform of common signals (Tutorial/Assignment only).

MODULE 3 (9 hours)

Characterization and Modeling of Continuous-time LTI Systems

Review of Laplace transform. Differential equation representation of continuous-time LTI systems, transfer function representation of differential equation.

Modeling of LTI systems - electrical, and translational and rotational mechanical systems
Block diagram representation - open loop and closed loop systems, effect of feedback in systems, block diagram reduction, signal flow graph - Mason's gain formula.

MODULE 4 (9 hours)

Frequency Domain Characterization of Discrete-time Signals and Systems

Sampling process - impulse train sampling, sampling theorem - aliasing effect, signal reconstruction - zero order and first order hold circuits.

Discrete-time (DT) Fourier series - properties, discrete-time Fourier transform (DTFT) - properties, frequency response of simple DT systems - magnitude response and phase response.

MODULE 5 (9 hours)

Characterization and Modeling of Discrete-time LTI Systems

Z-transform - region of convergence, Z-transform of standard signals, properties of Z-transform, Inverse Z-transform - partial fraction method.

Difference equation representations of LTI systems - analysis, Z-transfer function - delay operator, block diagram representation - direct form, cascade and parallel representations of 2nd order systems.

Use simulation software like MATLAB/Scilab to obtain Z-transform of common signals (Tutorial/Assignment only).

Text Books

1. Simon Haykin, Barry Van Veen, *Signals and Systems*, Wiley, 2nd ed., 2007.
2. Oppenheim A.V., Willsky A.S. & Nawab S.H., *Signals and Systems*, Prentice Hall, 2nd ed., 2015.
3. Nagrath I. J, Saran S. N and Ranjan R, *Signals and Systems*, Tata McGraw-Hill, 2nd ed., 2012.
4. Nagarath I. J. and Gopal M., *Control System Engineering*, New Age Publishers, 8th ed., 2024.

Reference Books

1. John G. Proakis & Dimitris G. Manolakis, *Digital Signal Processing Principles*, Prentice Hall, 4th ed., 2007.
2. Kumar, A. Anand, *Signals and Systems*, PHI Learning, 3rd ed., 2012.
3. Farooq Husain, *Signals and Systems*, Umesh publications, 2nd ed., 2005.
4. Nise N. S., *Control Systems Engineering*, Wiley Eastern, 6th ed., 2018.
5. Bracewell R.N., *Fourier Transform & Its Applications*, McGraw Hill, 3rd ed., 1999.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	46 Hours
	Module 1: Introduction to Signals and Systems	10
1.1	Concept of signals -Continuous and discrete-time signals -practical examples, elementary signals	1
1.2	Classification of signals, basic operations on continuous-time signals	1
1.3	Basic operations on discrete-time signals	1
1.4	Concept of system - classification of systems	1
1.5	Properties of systems - time invariance	1
1.6	Properties of systems - linearity	1
1.7	Properties of systems - causality - memory - stability	1
1.8	Practical examples of LTI systems - electrical, mechanical and thermal systems	1
1.9	Step response, impulse response - convolution integral and convolution sum	2
	Module 2: Frequency Domain Characterization of Continuous-time Signals and Systems	9
2.1	Fourier Series - Existence	1
2.2	Fourier Series - harmonic analysis of common signals	2
2.3	Fourier transform - Existence, Fourier transform of common Signals	2
2.4	Properties of Fourier transform	1
2.5	Energy spectral density, and power spectral density	1
2.6	Concept of frequency response - magnitude response, phase response	2
	Module 3: Characterization and Modeling of Continuous-time LTI Systems	9
3.1	Laplace transform (Review only)	1
3.2	Differential equation representation of continuous-time LTI systems, transfer function representation of differential equation	1
3.3	Modeling of LTI systems - electrical systems	1
3.4	Modeling of LTI systems - translational mechanical systems	1
3.5	Modeling of LTI systems - rotational mechanical systems	1
3.6	Block diagram representation - Open loop and closed loop systems, effect of feedback in systems	1
3.7	Block diagram reduction	1
3.8	Signal flow graph - Mason's gain formula	2
	Module 4: Frequency Domain Characterization of Discrete-time Signals and Systems	9

4.1	Sampling process - Impulse train sampling	1
4.2	Sampling theorem - Nyquist rate-aliasing effect	1
4.3	Signal reconstruction - zero order and first order hold circuits	1
4.4	Discrete-time (DT) Fourier series - properties	1
4.5	Discrete-time Fourier Transform (DTFT)	1
4.6	Discrete-time Fourier Transform (DTFT) - properties	2
4.7	Frequency response of simple DT systems - magnitude response and phase response	2
	Module 5: Characterization and Modeling of discrete-time LTI	9
5.1	Z-transform - Region of convergence, Z-transform of standard signals	2
5.2	Properties of Z-transform	1
5.3	Inverse Z-transform- partial fraction method	1
5.4	Difference equation representations of LTI systems - analysis	1
5.5	Z-transfer function - delay operator, block diagram representation - direct form	2
5.6	Block diagram representation - cascade representations of 2nd order systems	1
5.7	Block diagram representation - parallel representations of 2nd order systems	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Solve problems on basic signals and their operations.
2. Solve problems with properties of continuous and discrete time systems.
3. Solve problems based on types of systems using the convolution integral and sum.

Course Outcome 2 (CO 2)

1. Find the Fourier series of common signals.
2. State and prove the Fourier transform properties.
3. Obtain the frequency response of a given LTI system.

Course Outcome 3 (CO 3)

1. Obtain the differential equation representation of given continuous-time LTI systems.
2. Solve problems on block diagram reduction.
3. Reduce the given block diagram using Mason's Gain Formula.

Course Outcome 4 (CO 4)

1. State and prove the sampling theorem.
2. Solve problems related to discrete transfer function and impulse response.
3. Determine the discrete Fourier transform and frequency response of the given system.

Course Outcome 5 (CO 5)

1. Solve problems related to the realization of discrete-time systems.
2. Obtain the Z-transform and ROC of a given discrete-time signal.
3. Obtain all possible Inverse Z-transform.

MODEL QUESTION PAPER

QP CODE:

Pages: 4

Reg. No.:

Name:

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),
KOTHAMANGALAM

FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2026

Course Code: : B24EE2T05

Course Name: : SIGNALS AND SYSTEMS

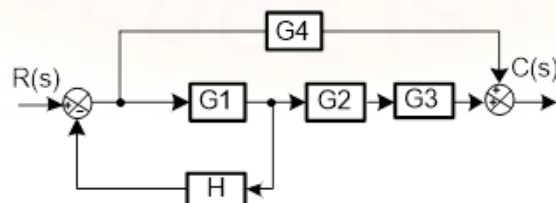
Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define unit step signal. Sketch the signal $u(t) - u(t + 2)$, where $u(t)$ is the unit step signal.
2. Check whether the following systems are linear or not.
(a) $y(t) = x(t^2)$
(b) $y(t) = e^{-2x(t)}$
3. Explain the Dirichlet's conditions for the existence of Fourier Series.
4. Obtain the Fourier Transform of $e^{-at}u(t)$.
5. Construct the signal flow graph for the following system represented by the block diagram.



6. Describe Mason's gain formula for signal flow graph.
7. Explain a ZOH circuit and derive its transfer function.

8. Obtain the transfer function of the given discrete time system described by the difference equation $y(n) - \frac{5}{4}y(n-1) + \frac{1}{6}y(n-2) = 2x(n)$.
9. State and prove any two properties of Z-transform.
10. Obtain the Z-transform and ROC of the signal $x(n) = 2^n u(n)$.

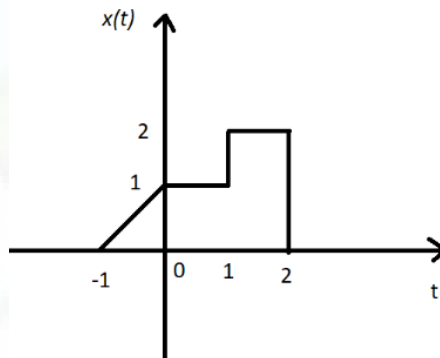
PART B

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

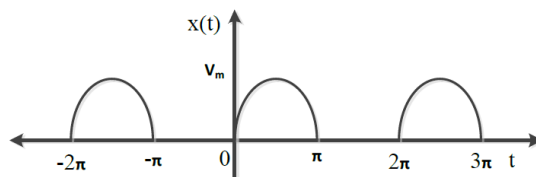
11. (a) Obtain the convolution of the following signals.
 $x_1(t) = e^{-2t}u(t)$ and $x_2(t) = e^{-4t}u(t)$ (7 marks)
- (b) Differentiate energy and power signals. Determine the energy and power of the signal $x(t) = (1 + e^{-2t})u(t)$. (7 marks)

OR

12. (a) Determine whether the system $y(n) = nx(n)$ is i) linear ii) time-invariant iii) dynamic and iv) causal. (7 marks)
- (b) The signal $x(t)$ is given below, draw the signals, (a) $x(t+3)$ (b) $x(-2t+2)$. (7 marks)



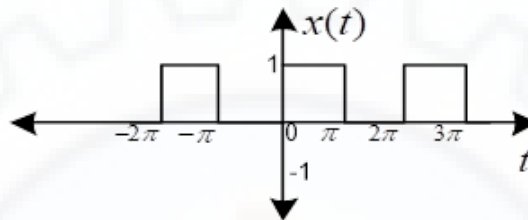
13. (a) Find the trigonometric Fourier series for the half-wave rectified sine wave shown in figure. (10 marks)



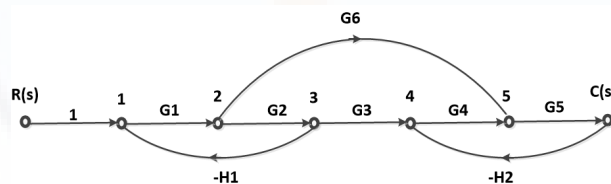
- (b) State and prove the time differentiation property of the Fourier transform. (4 marks)

OR

14. (a) Obtain the trigonometric Fourier series of the signal given below. (7 marks)



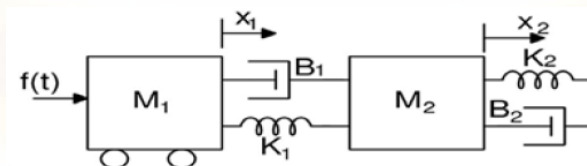
- (b) The input and output relationship of a causal system is described by $\frac{d^2y(t)}{dt^2} + 3\frac{dy(t)}{dt} + 2y(t) = x(t)$, (i) Obtain the frequency response of the system (ii) Find the impulse response of the system. (7 marks)
15. (a) The signal flow graph of a control system is shown in figure. obtain the transfer function $\frac{C(s)}{R(s)}$. (10 marks)



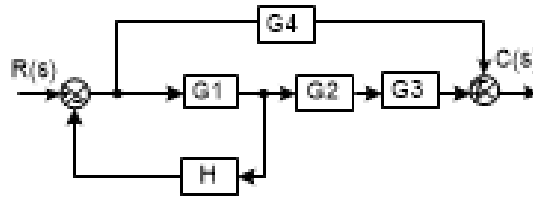
- (b) Determine the transfer function of the given LTI system $\frac{d^2y(t)}{dt^2} + 3\frac{dy(t)}{dt} + 2y(t) = 2\frac{dx(t)}{dt} - 3x(t)$. (4 marks)

OR

16. (a) Derive the transfer function $\frac{X_2(s)}{F(s)}$ of the given mechanical system. (10 marks)



- (b) Determine the overall transfer function for the system shown below. (4 marks)



17. (a) State and prove sampling theorem with necessary figures. (8 marks)
 (b) State and prove the time reversal property of Discrete-time Fourier transform. (6 marks)

OR

18. (a) Calculate the Nyquist rate and Nyquist interval for the signal,
 $x(t) = \sin 200\pi t + \cos 100\pi t$. (6 marks)
 (b) Determine the DTFS of $\{ \dots, 3, 2, -2, 1, \underset{\uparrow}{3}, 2, -2, 1, \dots \}$. (8 marks)
19. (a) Find the inverse z-transform of $X(z)$
 $X(z) = \frac{3z^{-1}}{(1-z^{-1})(1-2z^{-1})}$ if ROC is i) $|z| > 2$ ii) $|z| < 1$. (6 marks)
 (b) An LTI system is described by the difference equation
 $y(n) - \frac{9}{4}y(n-1) + \frac{1}{2}y(n-2) = x(n) - 3x(n-1)$.
 Specify the ROC of $H(z)$ and determine $h(n)$ for the following conditions i) the system is stable ii) the system is causal. (8 marks)

OR

20. The system function of a discrete-time system is $H(z) = \frac{(1-z^{-1})^4}{(1-z^{-1}+\frac{7}{8}z^{-2})(1+2z^{-1}+\frac{3}{4}z^{-2})}$.
 Realize the system using a cascade of a second-order system in direct form II. (14 marks)

B24EE2T06	POWER ELECTRONICS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course aims to introduce the fundamental principles and applications of power electronics, covering power semiconductor devices, power conversion techniques, and PWM strategies essential for modern electrical and electronic systems. The course covers power semiconductor devices, phase-controlled rectifiers, inverters, DC-DC converters, and AC-AC converters. Provides an in-depth understanding of device characteristics, switching techniques, harmonic effects, and efficiency considerations in power electronic circuits. On completion of this course, students will be able to analyze and design power electronic circuits, evaluate the performance of power converters, and apply power electronic principles in industrial and renewable energy applications.

Prerequisites

Electronics Circuits I, Circuits and Networks.

Course Outcomes

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

CO 1	Analyze the characteristics of power semiconductor devices, and demonstrate their switching principles and circuit implementations. (Cognitive Knowledge Level: Understand)
CO 2	Analyze the operation and performance of single-phase and three-phase phase-controlled rectifiers with various loads in continuous and discontinuous conduction modes. (Cognitive Knowledge Level: Apply)
CO 3	Understand the operation of single-phase and three-phase inverters and compare different PWM techniques. (Cognitive Knowledge Level: Understand)
CO 4	Apply appropriate design and control techniques to analyze DC-DC converters under various operating modes. (Cognitive Knowledge Level: Apply)
CO 5	Understand the operation of AC voltage controllers and cycloconverters, analyze their performance with different loads, and evaluate their applications. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% 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/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 (11 hours)

Introduction to Power Electronics

Power Electronics - scope and application, unipolar and bipolar switches, ideal and practical switches - characteristics, losses, EMI.

Power Semiconductor Devices

Thyristors - Basic structure, static and dynamic characteristics, two transistor analogy, methods of turning on, gate triggering circuits - R, RC, Snubber circuits.

Power Diodes and Power Transistor - Basic structure, static and dynamic characteristics.

Power MOSFET and IGBT - structure and operational principle, switching characteristics.

Wide band gap devices (GaN, SiC) - Advantages over silicon devices - Properties.

MODULE 2 (9 hours)

Phase Controlled Rectifiers using SCR (AC-DC Converters)

Single-phase - half wave-controlled rectifiers, half and fully-controlled converters - R, RL, RLE loads - continuous and discontinuous current operation. Analysis - average voltage, input side harmonics, and power factor. Line commutated inverters.

Three-phase - half-wave-controlled rectifier with R and RL loads, full wave fully controlled converters - R, RL, RLE loads - continuous current operation.

MODULE 3 (9 hours)

Inverters (DC-AC Converters)

Voltage source inverters - single-phase - half-bridge inverters and full-bridge inverters - square wave operation, harmonics due to switching, minimization of harmonics.

Introduction to PWM - single pulse and multiple pulse modulation, sinusoidal PWM - advantages, unipolar PWM, bipolar PWM - comparison.

Three-phase inverters - square wave operation (120° and 180°) - comparison, SPWM in three-phase inverters.

MODULE 4 (8 hours)

DC-DC Converters

Choppers - step-down and step-up choppers - single-quadrant, two-quadrant, and four-quadrant choppers, pulse width modulation, and current limit control in DC-DC converters.

Switching regulators - buck, boost, and buck-boost, operation with continuous conduction mode, waveforms, design - switch selection, filter inductance, and capacitance.

MODULE 5 (8 hours)

AC-AC Converters

AC Voltage Controllers (ACVC) - single-phase full-wave ACVC with R and RL loads - waveforms - RMS output voltage, input power factor with R load.

Cycloconverters – single-phase cycloconverters - principle of operation, types - mid-point and bridge type cycloconverters, three-phase cycloconverters - three-phase to single-phase, three-phase to three-phase, advantages, and disadvantages, applications.

Use simulation software to simulate power electronic converters to enhance practical understanding (Tutorial/Assignment only).

Text Books

1. Rashid M. H., *Power Electronics Circuits, Devices and Applications*, Prentice Hall India, 3rd ed., 2009.
2. Daniel W. Hart, *Power Electronics*, Tata McGraw-Hill Education, Vol.1, 3rd ed., 2011.
3. P. S. Bimbhra, *Power Electronics*, Khanna Publishers, 4th ed., 2012.
4. M. D. Singh and K. B. Khanchandani, *Power Electronics*, Power Electronics, 2nd ed., 2006.
5. B. J. Baliga, , *Fundamentals of Power Semiconductor Devices*, Springer , 2nd ed., 2019.

Reference Books

1. Mohan, Underland and Robbins, *Power Electronics: Converters, Applications and Design*, John Wiley & Sons, 3rd ed., 2003.
2. Robert W. Erickson and Dragan Maksimović, *Fundamentals of Power Electronics*, Springer Nature, 3rd ed., 2020.
3. G. K. Dubey, *Thyristorised Power Controllers*, Wiley Eastern Ltd, 1993.
4. Straughen and Dewan, *Power Semiconductor Circuits*, John Wiley & Sons, 1975.
5. Cyril W. Lander, *Power Electronics*, McGraw Hill, 3rd ed., 1993.
6. John G. Kassakian, Martin F. Schlecht, and George C. Verghese, *Principles of Power Electronics*, Cambridge University Press, 2nd ed., 2023.
7. Muhammad H. Rashid, *Power Electronics Handbook*, Academic Press, 4th ed., 2017.
8. P. C. Sen, *Principles of Electric Machines and Power Electronics*, John Wiley & Sons, 2nd ed., 1996.
9. Bimal K. Bose, *Modern Power Electronics and AC Drives*, Prentice Hall, 1st ed., 2001.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Introduction to Power Electronics and Power Semiconductor Devices	11
1.1	Scope and Application, unipolar and bipolar switches, Ideal and Practical switches -characteristics - losses, EMI	1
1.2	Thyristors - Basic structure, static and dynamic characteristics	1
1.3	Two transistor analogy	1
1.4	Methods of turning on, gate triggering circuits -R, RC triggering	2
1.5	Snubber circuits	1
1.6	Power Diode: Basic structure, Static and dynamic characteristics	1
1.7	Power Transistor: Basic structure, Static and dynamic characteristics	1
1.8	Power MOSFET and IGBT: Structure and operational principle, switching characteristics	2
1.9	Wide band gap devices (GaN, SiC): Advantages over silicon devices - Properties	1
	Module 2: Phase Controlled Rectifiers using SCR (AC-DC)	9
2.1	Single Phase Half wave-controlled rectifier- R, RL, RLE loads - continuous and discontinuous current operation, Analysis	2
2.2	Single Phase Semi converter - R, RL, RLE loads, Analysis	2
2.3	Single Phase Full converter - R, RL, RLE loads, Analysis	1
2.4	Line commutated inverters	1
2.5	Three Phase: Half wave-controlled rectifier with R and RL loads, Analysis	2
2.6	Three Phase fully controlled converters - R, RL, RLE loads - continuous current operation	1
	Module 3: DC-AC Converters	9
3.1	Single-phase half-bridge inverters and full-bridge inverters - square wave operation, harmonics due to switching, minimization of harmonics	2
3.2	Introduction to PWM - single pulse and multiple pulse modulation	2
3.3	Sinusoidal PWM - advantages	1
3.4	Unipolar PWM, bipolar PWM - comparison	1
3.5	Three-phase inverters - square wave operation (120° and 180°) - comparison	2
3.6	SPWM in three-phase inverters	1

	Module 4: DC-DC Converters	8
4.1	Step-down and step-up choppers	1
4.2	Single-quadrant and two-quadrant choppers	2
4.3	Four-quadrant choppers	1
4.4	Pulse width modulation, and current limit control in DC-DC converters	1
4.5	Buck converter - continuous conduction mode, waveforms, design	1
4.6	Boost converter - continuous conduction mode, waveforms, design	1
4.7	Buck Boost converter - continuous conduction mode, waveforms, design	1
	Module 5: AC-AC Converters	8
5.1	Voltage Controllers (ACVC) - single-phase full-wave ACVC with R and RL loads - waveforms - RMS output voltage, input power factor with R load	2
5.2	Single-phase mid-point type cycloconverters - principle of operation	1
5.3	Single-phase bridge type cycloconverters - principle of operation	1
5.4	Three-phase cycloconverters - three-phase to single-phase- advantages, and disadvantages, applications	2
5.5	Three-phase cycloconverters - three-phase to three-phase, - advantages, and disadvantages, applications	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the significance of power electronics in modern electrical and electronic systems.
2. With examples compare unipolar and bipolar switches in terms of their switching characteristics and performance.
3. Analyze the role of the two-transistor analogy in explaining the behavior of a thyristor.
4. Explain the basic structure and working principle of a power diode. Also draw the static and dynamic characteristics.
5. How the wider band gap in GaN and SiC devices contributes to lower power losses?

Course Outcome 2 (CO 2)

1. Describe the difference between continuous and discontinuous current operation in rectifiers.
2. Explain the effect of increasing the firing angle on the power factor of a single-phase rectifier.
3. Analysis of single phase rectifiers.
4. Analyze the operation of three-phase full-wave rectifier at various firing angles.
5. Describe how a single-phase rectifier can function as a line-commutated inverter.

Course Outcome 3 (CO 3)

1. Explain the square wave mode operation of a single phase half bridge inverter.
2. Define pulse-width modulation (PWM) and its purpose in inverters.
3. Describe the difference between single-pulse and multiple-pulse modulation.
4. Compare unipolar PWM and bipolar PWM.
5. Explain the operation of a three-phase square wave inverter in 120° and 180° conduction modes.

Course Outcome 4 (CO 4)

1. Analyze the performance of a four-quadrant chopper in regenerative braking applications.
2. Design a buck converter for a given input voltage, output voltage, and load current.
3. What are the control strategies used in DC-DC converters for voltage control?
4. Analyze the operation of a buck converter with necessary waveforms during CCM operation.
5. Apply the inductor and capacitor selection criteria to minimize current and voltage ripple in a boost converter.

Course Outcome 5 (CO 5)

1. Explain the basic working principle of a single-phase cycloconverter.
2. Explain how a three-phase to single-phase cycloconverter operates.
3. Discuss the applications of cycloconverters in industries.
4. Describe how a cycloconverter achieves variable frequency operation.
5. Explain how the output frequency of a cycloconverter is controlled.

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: : B24EE2T06

Course Name: : POWER ELECTRONICS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. List out the different turn-on methods of SCR. Explain any one method.
2. Explain the characteristics and advantages of wide band gap devices.
3. A single-phase full converter feeds power to RLE load with $R = 6 \Omega$, $L = 6 \text{ mH}$ and $E = 60 \text{ V}$. The AC voltage source is 230 V, 50 Hz. For continuous conduction, find the average value of load current for a firing angle of 30° and 60° .
4. Explain the significance of freewheeling operation in semi-converters.
5. Define Modulation Index and Modulation Frequency in PWM.
6. Explain half-bridge square wave voltage source inverter.
7. Explain Current Limit Control in chopper circuits.
8. What is meant by continuous conduction mode in the context of switching regulators?
9. Explain the effect of an RL load on the output waveform of a single-phase ACVC.
10. What is a cycloconverter? List out some of its applications.

PART B

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

11. (a) Explain the basic structure of a thyristor and describe its static and dynamic characteristics in detail. (7 marks)
- (b) Discuss the two-transistor analogy of a thyristor and explain how it helps in understanding thyristor operation. (7 marks)

OR

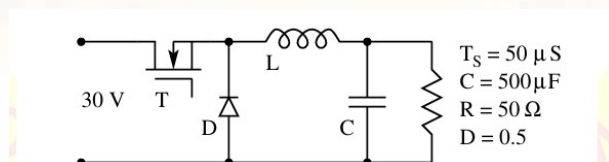
12. (a) Explain the working of R and RC gate triggering circuits with neat circuit diagrams. (7 marks)
 - (b) Explain the structure and operational principle of a Power MOSFET and discuss its advantages over BJTs. (7 marks)
13. Explain the working of a half-wave-controlled rectifier feeding RL load, with necessary waveforms. Derive the expression for average voltage, input side harmonics and power factor. (14 marks)

OR

14. (a) Explain the working of three phase fully controlled bridge rectifier, feeding RL load, with 60° firing angle. (7 marks)
 - (b) A three-phase, full-wave bridge rectifier containing six ideal thyristors supplies a resistive load $R=100\ \Omega$. The ideal supply 240 V, 50 Hz provides balanced sinusoidal voltages. Calculate the average load current and power dissipation at (a) 30° , (b) 60° , and (c) 90° . (7 marks)
15. (a) Explain the need for PWM in inverters. Discuss the principle of sinusoidal PWM (SPWM) and its advantages over square wave operation. (7 marks)
- (b) Explain the multiple pulse width modulation used in a single-phase inverter and draw relevant waveforms. (7 marks)

OR

16. Compare 120° and 180° conduction modes of three phase inverters with circuit diagram and waveform analysis. (14 marks)
17. Figure shows a non-isolated buck converter operating at a duty ratio of 0.5 at a switching frequency of 20 kHz. The components may be taken to be ideal.



- i. Evaluate the value of L such that the converter operates in the discontinuous mode.
- ii. Evaluate the diode conduction time and the output voltage under such conditions.

(14 marks)

OR

18. A boost converter is used to step up a DC voltage from 12 V to 24 V to power a load. The converter operates at a switching frequency of 20 kHz, and the inductor value is 1 mH. The output power required by the load is 48 W. Assume the circuit operates in continuous conduction mode (CCM). Determine the duty cycle required to achieve the desired output voltage, the average input current drawn from the supply, the peak-to-peak inductor current ripple, If a 220 μ F capacitor is used as an output filter, determine the ripple voltage across the capacitor and the efficiency of the converter if the total power loss in the circuit is 2 W.

(14 marks)

19. Explain the difference between phase-angle control and integral cycle control in AC voltage controllers.

(14 marks)

OR

20. Describe how the three-phase input is converted to a single-phase output in this type of cycloconverter.

(14 marks)

B24EE2T07	ELECTROMAGNETIC THEORY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The course aims to equip the students with an understanding of the fundamental principles of static and time varying Electromagnetic fields. This is accomplished by a strong conceptual understanding of basic laws and theorems of electromagnetics and its applications with the art of technical problem solving. Upon successful completion of the course, the students will be empowered to analyze and comprehend the diverse static and dynamic electromagnetic systems that surround us.

Prerequisites

Nil

Course Outcomes

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

CO 1	Apply fundamental concepts of coordinate systems and basic laws of electromagnetics to solve static electric fields. (Cognitive Knowledge Level: Apply)
CO 2	Understand and apply the basic concepts of electric potential, capacitance, divergence of vector fields to solve various electromagnetic problems. (Cognitive Knowledge Level: Understand)
CO 3	Understand and apply the basic laws and theorems along with the concepts of curl and boundary conditions of static and time-varying electromagnetic fields to solve electromagnetic problems. (Cognitive Knowledge Level: Apply)
CO 4	Apply Maxwells equations to develop and analyse electromagnetic wave equations of different mediums and its various parameters. (Cognitive Knowledge Level: Apply)
CO 5	Apply and analyse wave propagation through transmission lines and its characteristics. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	1	1		1	1		1		2
CO 2	3	3	1	1		1	1		1		2
CO 3	3	3	1	1		1	1		1		2
CO 4	3	3	1	1		1	1		1		2
CO 5	3	3	1	1		2	2		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/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)

Co-ordinate Systems and Static Electric Fields

Review of coordinate systems - rectangular, cylindrical, and spherical coordinate systems - coordinate transformation between cartesian-cylindrical and cartesian-spherical. Static electric fields - Coulomb's law, electric field intensity, field due to a line charge, surface charge distribution. Electric flux and flux density, Gauss's law and its application - the field due to an infinite line charge, infinite sheet charge.

MODULE 2 (6 hours)

Electric Potential and Capacitance

Electric potential - gradient of a scalar field, potential gradient, conservative property of electric field, equipotential surfaces. Capacitance - capacitance of co-axial cable, two wire lines, divergence of a vector field - physical interpretation, Divergence theorem, Poisson's and Laplace's equations.

MODULE 3 (9 hours)

Static Magnetic Fields and Introduction to Time-varying Fields

Introduction to magnetic flux, flux density, magnetic field intensity, self inductance. Static magnetic fields - Biot-Savart's Law, magnetic field intensity due to a - finite and infinite wire carrying current, on the axis of a circular loop carrying current, magnetic flux density, ampere's circuital law, and simple applications, curl of a vector field - physical interpretation, Stokes' Theorem. Boundary conditions for electric fields and magnetic fields. Conduction current and displacement current densities, continuity equation for current. Modified form of Ampere's circuital law, Faraday's Law, and Gauss's Law - Maxwell's equation in differential and integral form.

MODULE 4 (7 hours)

Electromagnetic Waves

Introduction to electromagnetic waves, Poynting vector, and Poynting theorem. Uniform plane waves, wave equations from Maxwell's equation in phasor form, propagation of uniform plane waves in free space, loss-less and lossy dielectric medium, uniform plane waves in good conductor, transverse nature of electromagnetic waves, skin effect and skin depth, intrinsic impedance, attenuation constant, and propagation constant in all mediums.

MODULE 5 (6 hours)

Transmission Line

Transmission line parameters, transmission line equation, and solutions, propagation constants, characteristic impedance, wavelength, velocity of propagation. Standing wave ratio (SWR), reflection coefficient, impedance matching - solution of problems, electromagnetic interference.

Text Books

1. Matthew N. O. Sadiku, *Principles of Electromagnetics*, Oxford University Press, 6th ed., 2015.
2. Hayt W. H. and J. A. Buck, *Engineering Electromagnetics*, McGraw-Hill, 9th ed., 2019.
3. P. M. Ramanathan K. A. Gangadhar *Electromagnetic Theory*, Khanna Publishers, 2009.

Reference Books

1. Joseph Edminister, Mahmood Nahvi, *Electromagnetics*, Schaum's Outlines, 4th ed., 2013.
2. John Kraus and Daniel Fleisch, *Electromagnetics with applications*, McGraw-Hill Education, 5th ed., 2017.
3. S. P. Seth, *Elements of Electromagnetic fields*, Dhanpat Rai Publishing Co Pvt Ltd, 2001.
4. David K. Cheng, *Fundamentals of Engineering Electromagnetics*, Pearson Education, 1st ed., 2019.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	37 Hours
	Module 1: Co-ordinate Systems and Static Electric Fields	9
1.1	Review of coordinate systems - rectangular, cylindrical, and spherical coordinate systems	2
1.2	Coordinate transformation between cartesian-cylindrical and cartesian-spherical.	2
1.3	Static electric fields - Coulomb's law, electric field intensity, field due to a line charge, surface charge distribution	2
1.4	Electric flux and flux density, Gauss's law and its application - the field due to an infinite line charge, infinite sheet charge, Numerical problems	2
1.5	Numerical problems	1
	Module 2: Electric Potential and Capacitance	6
2.1	Electric potential - gradient of a scalar field, electric potential - potential gradient, conservative property of electric field, equipotential surfaces, Numerical problems	2
2.2	Capacitance - capacitance of co-axial cable, two wire lines (concept and equations only), Numerical problems	2
2.3	Divergence of a vector field- physical interpretation, Divergence theorem, Poisson's and Laplace's equations	2
	Module 3: Static Magnetic Fields and Introduction to Time-varying Fields	9
3.1	Introduction to magnetic flux, flux density, magnetic field intensity, self inductance	1
3.2	Static magnetic fields - Biot-Savart's Law, magnetic field intensity due to a - finite and infinite wire carrying current, on the axis of a circular loop carrying current, magnetic flux density	2
3.3	Numerical problems	1
3.4	Ampere's circuital law, and simple applications	1
3.5	Curl of a vector field - physical interpretation, Stokes' Theorem, numerical problems	1
3.6	Boundary conditions for electric fields and magnetic fields	1
3.7	Conduction current and displacement current densities, continuity equation for current. Modified form of Ampere's circuital law, Faraday's Law, and Gauss's Law- Maxwell's equation in differential and integral form	2
	Module 4: Electromagnetic Waves	7
4.1	Introduction to electromagnetic waves, Poynting vector, and Poynting theorem	1

4.2	Uniform plane waves, wave equations from Maxwell's equation in phasor form, propagation of uniform plane waves in free space, lossless and lossy dielectric medium, uniform plane waves in good conductor	2
4.3	Numerical problems	1
4.4	Transverse nature of electromagnetic waves, skin effect and skin depth, intrinsic impedance, attenuation constant, and propagation constant in all mediums. Numerical problems	2
4.5	Numerical problems	1
	Module 5: Transmission Line	6
5.1	Transmission line parameters, transmission line equation, and solutions	2
5.2	Propagation constants, characteristic impedance, wavelength, velocity of propagation- Numerical problems	2
5.3	Standing wave ratio (SWR), reflection coefficient, impedance matching - solution of problems, electromagnetic interference	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Solve problems based on coordinate transformation.
2. Solve problems using Coloumb's law in static electric fields.
3. Explain Gauss's law and its applications.

Course Outcome 2 (CO 2)

1. Evaluate Problems on electric potential.
2. State and derive Divergence of a vector field.
3. Explain Poisson's and Laplace's equation.

Course Outcome 3 (CO 3)

1. Explain Biot Savart's law and its applications.
2. Develop the boundary conditions of static magnetic fields.
3. Describe conduction and displacement currents.

Course Outcome 4 (CO 4)

1. Derive Poynting theorem and explain.
2. Derive wave equation of lossy dielectrics in phasor form.
3. Solve problems on propagation constants of EM waves in different mediums.

Course Outcome 5 (CO 5)

1. Derive the wave equations for a transmission line.
2. Solve problems on characteristic impedance of Transmission lines.
3. Explain terms standing wave ratio, reflection coefficient, EM interference.

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: B24EE2T07

Course Name: ELECTROMAGNETIC THEORY

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Describe the transformation of variables in cartesian coordinate system to its equivalent in cylindrical coordinate system.
2. State and explain Gauss's law for static electric fields.
3. Explain the conservative nature of electric field.
4. Define Divergence and explain its physical interpretation.
5. State and explain Ampere's circuital law for magnetic fields.
6. Compare Conduction current and Displacement current.
7. Define Poynting vector and its significance.
8. Define the term skin depth.
9. Explain characteristic impedance of a lossless transmission line.
10. Define the term standing wave ratio (SWR).

PART B

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

11. (a) Transform vector $A = 5a_r + 2\sin\phi a_\theta + 2\cos\theta a_\phi$ in spherical to Cartesian coordinate system. (6 marks)
- (b) Evaluate both sides of the Divergence theorem for the region $r \leq 1$ and if $A = 3r\sin 2\theta \cos^2 \phi a_r$. (8 marks)

OR

12. (a) Derive co-ordinate transformation between Cartesian and Spherical systems. (10 marks)
- (b) Explain the physical significance of divergence of a vector field. (4 marks)
13. (a) State and Prove Gauss's Law. (4 marks)
- (b) Four point charges are located at the four corners of the rectangle. Length and breadth of rectangle are 5 cm and 2 cm respectively. Find the magnitude and direction of the resultant force on Q_1 . (10 marks)

OR

14. (a) Derive the expression of electric field intensity due to infinite line charge having line charge density ρ C/m. (6 marks)
- (b) Using Gauss's Law derive an expression for the capacitance per unit length between two infinitely long concentric conducting cylinders. The medium between two cylinders is completely filled with air. (8 marks)
15. (a) State the boundary conditions at the boundary of two magnetic media of permeability μ_1 and μ_2 . (10 marks)
- (b) Flux lines are received at an iron-air boundary at 880. If the iron has a relative permeability of 350, determine the angle from the normal with which the flux emerges into air. (4 marks)

OR

16. (a) Find the incremental contribution ΔH to magnetic field intensity at the origin caused by a current element in free space, $IdL = 3a_z$ nA, located at (3,-4, 0). (8 marks)
- (b) Derive the magnetic field intensity on the axis of a circular loop carrying current. (6 marks)
17. (a) A 10 GHz plane wave traveling in free space has an amplitude 15 V/m. Find velocity of propagation, wavelength, amplitude of H, characteristic impedance of media, and propagation constant. (10 marks)
- (b) What is skin effect and skin depth? (4 marks)

OR

18. (a) Explain about Poynting Theorem. Show that the power flow along a concentric cable is the product of voltage and current using the Poynting Theorem. (10 marks)
- (b) What is a uniform plane wave? What are its properties? (4 marks)
19. (a) Explain in detail impedance matching of lines. (10 marks)
- (b) Explain the terms, propagation constant and phase velocity applied to transmission lines. (4 marks)

OR

20. (a) Derive the basic transmission line wave equation. (9 marks)
- (b) What are the different parameters of transmission lines? (5 marks)

B24HU2T01	BUSINESS ECONOMICS AND FINANCIAL MANAGEMENT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	0	0	4	3	2024

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:

CO 1	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)
CO 2	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)
CO 3	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)
CO 4	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)
CO 5	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

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% 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 MacMillan, 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
	Module 1: Fundamentals of Business Economics	8
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. Activity 2: Derive the determination of the equilibrium price of a super luxury and an economy car	
	Module 2: Cost, Revenue and Markets	7
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 Activity 2: Pricing strategy followed by Apple in regard to their mobiles	
	Module 3: National Income, Inflation and International Trade	7
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 Activity 2: Impact of tariff wars in today's global scenario	
	Module 4: Financial Management	7
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. Activity 2: Steps needed to circumnavigate financial challenges like student loans, buying a car, purchasing a home vs renting etc.	
	Module 5: Business Financing	7
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. 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 ATHANASIOUS 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)

B24EE2T08	MICROPROCESSORS AND MICROCONTROLLERS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	2	0	5	4	2024

Preamble

This course aims to provide a comprehensive understanding of microprocessors, microcontrollers, and embedded systems, equipping students with essential knowledge of programming and system design. The course covers the 8085 microprocessor, assembly language programming, embedded systems fundamentals, Arduino, and ARM-based development. By the end of the course, students will be able to design and develop embedded applications and find efficient solutions for real-world challenges in industrial automation.

Prerequisites

Problem Solving and Programming Techniques.

Course Outcomes

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

CO 1	Understand the internal architecture, instruction set, and execution process of the 8085 microprocessor, including machine cycles and timing diagrams. (Cognitive Knowledge Level: Understand)
CO 2	Develop and implement assembly language programs for the 8085 microprocessor to perform arithmetic operations, data handling, and interrupt handling. (Cognitive Knowledge Level: Apply)
CO 3	Understand embedded system fundamentals, microcontroller architecture, and design real-time system applications, with a focus on Arduino-based development. (Cognitive Knowledge Level: Apply)
CO 4	Design and implement embedded applications using Arduino, including sensor interfacing, actuator control, and real-time data processing. (Cognitive Knowledge Level: Apply)
CO 5	Understand ARM-based embedded system architecture, including ARM instruction sets, Raspberry Pi architecture, and real-world applications of microcontrollers. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% 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/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)

8085 Microprocessor

Internal architecture of 8085 microprocessor, functional block diagram, instruction set - addressing modes, classification of instructions - data transfer operations, arithmetic operations, logic operations, branching operations, I/O and machine control operations, status flags. Machine cycles and T states - fetch and execute cycles - timing diagram for instruction and data flow.

MODULE 2 (10 hours)

Assembly Language Programming

Assembly language programs (ALP) in 8085 microprocessor - data handling/data transfer, arithmetic operations, code conversion - BCD to binary - binary to BCD, sorting, stack and subroutines - conditional CALL and return instructions. Time delay subroutines using 8-bit register, 16-bit register pair, and nested loop control. Interrupt and interrupt handling - hardware and software interrupts, interrupt structure.

MODULE 3 (8 hours)

Embedded Systems

Introduction to embedded systems, current trends and challenges, applications of embedded systems - hard and soft real-time systems. Introduction to microcontrollers - microprocessor vs microcontroller. Introduction to Arduino UNO (8-bit) - hardware fundamentals of ATmega328P microcontroller-based board. Arduino architecture, pin diagram, and functions of pins - overview of main features such as I/O ports, timers, interrupts, PWM, ADC(introduction only). Introduction to Arduino IDE - Arduino libraries, steps for creating an Arduino program - Arduino sketch structure and flow- setup and loop functions.

MODULE 4 (9 hours)

Arduino Programming

Programming - data types - operators, conditional statements - loops, arrays and functions, built-in functions in Arduino, program to blink an LED and its control, interfacing LCD, seven segment LED, switch interface, binary counter working with LED controlled by switch/potentiometer, working with basic sensors and actuators using Arduino.

MODULE 5 (9 hours)

ARM (Advanced RISC Machines) based Embedded System Design

ARM architecture - RISC, CISC-ARM program model - pipeline (3/5 stage) - memory organization - privileged model - exceptions - ARM instruction set - overview of ARM CPU cores. Overview of Raspberry Pi - Introduction to Raspberry Pi, comparison of various Rpi models, understanding SoC architecture and SoCs used in Raspberry Pi, pin description of Rpi, on-board components of Rpi.

Seminar on applications of microcontrollers on consumer electronics (Tutorial/Assignment only).

Text Books

1. Ram, B. Dhanpat, *Fundamentals of Microprocessor and Micro controllers*, Dhanpat Rai Publications (P) Ltd., New Delhi, 8th ed., 2021.
2. Ramesh Gaonkar, *Microprocessor, Architecture, Programming and Applications*, Penram International Publishing, 6th ed., 2014.
3. Michael Margolis, *Arduino Cookbook*, O'Reilly Media, Inc., 3rd ed., 2020.
4. Steve Furber, *ARM System On Chip Architecture*, Addison-Wesley Publication, 2nd ed., 2000.
5. SM. Rafiquzzaman, *Microprocessor Theory and Application*, Wiley Publication, 1st ed., 2008.

Reference Books

1. Simon Monk, *Programming the Raspberry Pi, Getting Started with Python*, McGraw Hill Professional, 3rd ed., 2021.
2. Derek Molloy, *Exploring Raspberry Pi: Interfacing to the Real World with Embedded Linux*, Wiley publications, 1st ed., 2016.
3. CyberPunk Architects, *The Computer Programming Bible: A Step by Step Guide On How To Master From The Basics to Advanced of Python, C, C++, C#, HTML Coding Raspberry Pi3*, C.P.A Inc, 1st ed., 2020.
4. John C. Shovic, *Raspberry Pi IoT Projects: Prototyping Experiments for Makers*, APress, 1st ed., 2016.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: 8085 Microprocessor	9
1.1	Internal architecture of 8085 microprocessor	1
1.2	Functional block diagram	2
1.3	Instruction set - addressing modes - classification of instructions	2
1.4	Status flags-Machine cycles and T states	2
1.5	Fetch and execute cycles	1
1.6	Timing diagram for instruction and data flow	2
1.6	Solution of network equations by matrix representation	2
	Module 2: Assembly Language Programming	10
2.1	Introduction to assembly language programming - data transfer operations, arithmetic operations, logic operations, branching operations, I/O, and machine control operations	2
2.2	Assembly language programs (ALP) in 8085 microprocessor - data handling/data transfer, arithmetic operations	2
2.3	Code conversion - BCD to Binary - Binary to BCD	1
2.4	Sorting, stack and subroutines - conditional CALL and return instructions	1
2.5	Time delay subroutines using 8-bit register, 16-bit register pair, and nested loop control	2
2.6	Interrupt and interrupt handling - hardware and software interrupts	2
	Module 3: Embedded Systems	8
3.1	Introduction to embedded systems, current trends and challenges, applications of embedded systems - hard and soft real-time systems	2
3.2	Introduction to microcontrollers - microprocessor vs microcontroller. Introduction to Arduino UNO (8-bit) - hardware fundamentals of ATmega328P microcontroller-based board	2
3.3	Arduino Architecture, pin diagram, and functions of pins - overview of main features such as I/O ports, timers, interrupts, PWM, ADC (introduction only)	2
3.4	Introduction to Arduino IDE - Arduino libraries, steps for creating an Arduino program- Arduino sketch structure and flow- setup and loop functions(simple programs)	2
	Module 4: Arduino Programming	9
4.1	Programming - data types- operators	1
4.2	Conditional statements - loops, arrays and functions	1
4.3	Built-in functions in Arduino	1

4.4	Program to blink an LED and its control, interfacing LCD, seven segment LED	2
4.5	Switch interface, binary counter working with LED controlled by switch/potentiometer	2
4.6	Working with basic sensors and actuators using Arduino	2
	Module 5: ARM (Advanced RISC Machines) based Embedded System Design	9
5.1	ARM architecture - RISC, CISC	1
5.2	ARM program model- Pipeline (3/5 stage)	2
5.3	Memory organization - privileged model - exceptions	1
5.4	ARM instruction set(simple programs) - overview of ARM CPU cores	1
5.5	Overview of Raspberry Pi - Introduction to Raspberry Pi, comparison of various Rpi models	1
5.6	Understanding SoC architecture and SoCs used in Raspberry Pi, pin description of Rpi, on-board components of Rpi	2
5.7	Seminar on applications of microcontrollers on consumer electronics (Tutorial/Assignment only)	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Describe the register organization in 8085 microprocessor.
2. Explain the Stack and subroutine operations.
3. Draw the timing diagrams of different instructions of 8085 microprocessor.

Course Outcome 2 (CO 2)

1. Describe the addressing modes of 8085 microprocessor.
2. Describe the various types of 8085 microprocessor instructions.
3. Write an ALP for data transfer, arithmetic, logical and branching operations.

Course Outcome 3 (CO 3)

1. Explain the architecture of Arduino UNO.
2. Differentiate between microprocessor and microcontroller.

3. Differentiate hard and soft real systems.

Course Outcome 4 (CO 4)

1. Explain the working of sensors of Arduino UNO.
2. List the data types in Arduino UNO.
3. Differentiate hard and soft real systems.

Course Outcome 5 (CO 5)

1. Explain RISC ARM architecture.
2. Illustrate 3/5 pipeline stages of ARM program model.
3. Explain ARM memory organization.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg. No.:

Name:

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

FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2026

Course Code: : B24EE2T08

Course Name: : MICROPROCESSORS AND MICROCONTROLLERS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. List the control and status signals of 8085.
2. Explain the operation of the following 8085 instructions:
(i) DAD D (ii) INR M (iii) XCHG
3. Describe the addressing modes of 8085 microprocessor.
4. Write an ALP for data transfer, arithmetic, logical and branching operations.
5. Explain the architecture of Arduino UNO.
6. Differentiate hard and soft real systems.
7. Explain the working of sensors of Arduino UNO.
8. Write a program to control the externally connected LED blinking.
9. Explain RISC ARM architecture.
10. Explain ARM memory organization.

PART B

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

11. (a) Explain the architecture of 8085 microprocessor with the help of a neat diagram. (10 marks)
- (b) identify the machine cycles of the following instructions:
(i) MOV B, M (ii) MVI A, 05H (iii) STA 2065H (iv) OUT 01H. (4 marks)

OR

12. (a) Sketch and explain the timing diagram of the instruction MOV M, A with opcode 77H stored in the memory location 4500H. (9 marks)
- (b) Define PUSH and POP instructions of 8085. (5 marks)

13. Write a program to sort an array of 5 numbers in ascending order. (14 marks)

OR

14. Write an 8085 ALP to find 2' complement of an 8-bit number which is stored in location 2050H. (14 marks)
15. (a) Explain hard real-time considerations and soft real-time considerations. (4 marks)
- (b) Explain the main features of the ATmega328P microcontroller, and how do they influence the performance of the Arduino UNO. (10 marks)

OR

16. Arduino UNO considered an 8-bit microcontroller. Justify. (14 marks)
17. (a) Explain the data types in Arduino programming. (7 marks)
- (b) Explain conditional statements in Arduino, and how are they used to control program flow. (7 marks)

OR

18. (a) Illustrate the working of the digitalWrite() function work, and how do you use it to control an LED. (7 marks)
- (b) Write a program to display text on an LCD screen using the LiquidCrystal library. (7 marks)
19. (a) Differentiate between RISC (Reduced Instruction Set Computing) and CISC (Complex Instruction Set Computing). (7 marks)
- (b) Illustrate key differences between a 3-stage and 5-stage pipeline in terms of instruction processing and performance. (7 marks)

OR

20. (a) Explain Raspberry Pi, and its primary use cases in the fields of education, hobbyist projects, and embedded systems. (7 marks)
- (b) Explain the key differences between the Raspberry Pi 3, Raspberry Pi 4, and Raspberry Pi Zero models. (7 marks)

B24EE2L05	ELECTRICAL MACHINES LAB I	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

This course provides hands-on experience in operating and testing DC machines and transformers, reinforcing concepts such as voltage regulation, efficiency, and load performance. The course includes a series of experiments focused on the operation, performance analysis, and efficiency assessment of various electrical machines, including DC shunt generators, DC motors, and single-phase and three-phase transformers. By engaging with these experiments, students will develop a robust understanding of machine operations, enhance their analytical skills, and be well-prepared to tackle real-world challenges in the electrical engineering domain.

Prerequisite

DC Machines and Transformers.

Course Outcomes

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

CO 1	Analyze the performance characteristics of DC machines by conducting suitable no load/load tests. (Cognitive Knowledge Level: Apply)
CO 2	Determine the losses and efficiency in DC machines by conducting suitable no load/load tests. (Cognitive Knowledge Level: Apply)
CO 3	Determine the voltage regulation, efficiency, and losses of single phase and three phase transformers by conducting suitable no load/load tests. (Cognitive Knowledge Level: Apply)
CO 4	Understand the load sharing between parallel connected single-phase transformers by conducting suitable tests. (Cognitive Knowledge Level: Understand)
CO 5	Develop team management skills and prepare laboratory reports that logically and scientifically communicate experimental information. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Mark Distribution

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

Continuous Internal Evaluation Pattern

Attendance	10 marks
Continuous Assessment	15 marks
Performance	10 marks
Viva-Voce	5 marks
Lab Record	5 marks
Internal Exam	20 marks

End Semester Examination (ESE) Pattern:

The following guidelines should be followed regarding the award of marks

1. Preliminary work : 25 Marks
 - (a) Circuit Diagram: 15 Marks
 - (b) Theory and Procedure: 10 Marks
2. Implementing the work/Conducting the experiment : 30 Marks (usage of equipment and troubleshooting)
3. Result and Inference : 15 Marks
4. Viva Voce : 30 Marks

Students having a certified Lab record are only eligible to appear for the End Semester Examination.

SYLLABUS

LIST OF EXPERIMENTS

1	Plot Open Circuit Characteristics (OCC) of DC shunt generator to determine the critical field resistance and critical speed.
2	Load test on DC shunt and compound generator to plot the external and internal characteristics.
3	Brake test on DC shunt and series motors to plot their performance characteristics.
4	Swinburne's Test on a DC shunt machine to predetermine the efficiency of the machine when working as a motor and as a generator for various load conditions.
5	Hopkinson's test on a pair of DC machines to determine the efficiency of the DC machine while working as a motor and generator under various load conditions.
6	Retardation test on a DC machine to determine hysteresis, eddy current, friction and windage losses, and moment of inertia of the rotating system.
7	OC and SC tests on a single-phase transformer to predetermine the voltage regulation and efficiency at different loads and power factors.
8	Direct load test on a single-phase transformer to determine the voltage regulation and efficiency at different loads and power factors.
9	Sumpner's test on single phase transformers to predetermine regulation and efficiency at different loads and power factors.
10	Separation of constant losses of a single-phase transformer.
11	Parallel operation of two single-phase transformers.
12	OC and SC tests on a three-phase transformer to predetermine the efficiency and regulation at different load conditions and power factors.

Reference Books

1. P. S. Bimbhra, *Electrical Machinery*, Khanna Publishers, 7th ed., 2021.
2. D. P. Kothari and I. J. Nagrath, *Electric Machines*, Tata McGraw Hill, 5th ed., 2017.
3. B. L. Theraja , *A Textbook of Electrical Technology*, S. Chand and Company, 2014.
4. V. K. Mehta and Rohit Mehta, *Principles of Electrical Machines*, S. Chand and Company, 2014.
5. M. V. Deshpande, *Electrical Machines*, Prentice Hall India, 2011.
6. A. E. Fitzgerald, C. Kingsley and S. Umans, *Electric Machinery*, McGraw Hill, 6th ed., 2003.
7. A. E. Clayton and N. N. Hancock, *The Performance and design of Direct Current Machines*, CBS Publishers and Distributors, 2018.

B24EE2L06	ELECTRONIC CIRCUITS LAB II	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

This course aims to provide hands-on experience in designing and analyzing various analog and mixed-signal circuits using operational amplifiers, waveform generators, and data converters. The lab covers op-amp-based circuits, oscillators, multivibrators, ADC/DAC, and phase-locked loops, focusing on practical applications in signal processing and instrumentation. Upon completion, students will be able to design, implement, and test analog circuits, analyze their performance, and apply them in real-world electronic systems.

Prerequisite

Electronic Circuits II

Course Outcomes

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

CO 1	Understand and design fundamental operational amplifier circuits such as inverting, non-inverting, summing, integrator, and differentiator circuits and precision rectifiers for signal processing applications. (Cognitive Knowledge Level: Understand)
CO 2	Design, implement and test square and triangular wave generators, oscillators (RC Phase-Shift, Wien Bridge), and multivibrators (astable, monostable, Schmitt trigger) using op-amps and timers. (Cognitive Knowledge Level: Apply)
CO 3	Understand and implement Digital-to-Analog Converters (DAC), Analog-to-Digital Converters (ADC), and instrumentation amplifiers for measurement and signal conditioning applications. (Cognitive Knowledge Level: Understand)
CO 4	Understand the working of Phase-Locked Loops (PLL) as free-running oscillators and frequency multipliers in communication and control systems. (Cognitive Knowledge Level: Understand)
CO 5	Develop team management skills and prepare laboratory reports that logically and scientifically communicate experimental information. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Mark Distribution

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

Continuous Internal Evaluation Pattern

Attendance	10 marks
Continuous Assessment	15 marks
Performance	10 marks
Viva-Voce	5 marks
Lab Record	5 marks
Internal Exam	15 marks
Micro Project	5 marks

End Semester Examination (ESE) Pattern:

The following guidelines should be followed regarding the award of marks

1. Preliminary work : 25 Marks
 - (a) Circuit Diagram: 15 Marks
 - (b) Theory and Procedure: 10 Marks
2. Implementing the work/Conducting the experiment : 30 Marks (usage of equipment and troubleshooting)
3. Result and Inference : 15 Marks
4. Viva Voce : 30 Marks

Micro Project: Students must complete a mandatory micro project in groups of up to four members. The project should involve the design and realization of a functional analog circuit using an operational amplifier (Op-Amp), along with a small hardware implementation. This project will be evaluated as part of the continuous internal evaluation, with a maximum of 5 marks. **Students having a certified Lab Record and Micro Project Report are only eligible to appear for the End Semester Examination.**

SYLLABUS

LIST OF EXPERIMENTS

1	Design and implementation of inverting, non-inverting, summer, integrator, and differentiator circuits using Op-Amp.
2	Design and testing of Square and Triangular Wave Generator.
3	Design and testing of Precision Rectifier using Op-Amp.
4	Design and testing of RC Phase-Shift Oscillator using Op-Amp.
5	Design and testing of Wien Bridge Oscillator.
6	Design and testing of Schmitt Trigger.
7	Design and testing of Astable Multivibrator using IC 741.
8	Design and testing of Astable and Monostable Multivibrator Using IC 555.
9	Implementation of Instrumentation Amplifier Using IC 741.
10	Design and testing of Digital to Analog Converter (DAC) using a Weighted Resistor and Ladder Network.
11	Design and testing of Analog to Digital Converter (Flash ADC).
12	Implementation of Phase-Locked Loop as a Free-Running Oscillator and Frequency Multiplier.

Reference Books

1. Sergio Franco, *Design with Operational Amplifiers and Analog Integrated Circuits*, Tata McGraw-Hill, 4th ed., 2016.
2. D. Roy Choudhury and Shail Jain, *Linear Integrated Circuits*, New Age International Publishers, 4th ed., 2017.
3. Ramakanth A. Gayakwad, *Op-Amps and Linear Integrated Circuits*, Pearson Education, 4th ed., 2015.

4. Adel S. Sedra and Kenneth C. Smith, *Microelectronic Circuits*, Oxford University Press, 7th ed., 2014.
5. Boylestad R. L. and L. Nashelsky, *Electronic Devices and Circuit Theory*, Pearson Education India, 11th ed., 2012.
6. Donald O. Pederson and Kartikeya Mayaram, *Analog Integrated Circuits for Communication*, Kluwer Academic Publishers, 2nd ed., 2007.
7. Jacob Millman and Christos C. Halkias, *Electronic Devices and Circuits*, McGraw-Hill Education, 3rd ed., 2010.
8. Marcel J. M. Pelgrom, *Analog-to-Digital Conversion*, Springer Publishers, 3rd ed., 2020.

A large, faint watermark logo is centered on the page. It features a gear-like outer border. Inside the gear is a circle containing a cross. Below the cross is a stylized mountain range. At the base of the mountains is an open book. A banner at the bottom of the logo contains the text "KNOWLEDGE IS POWER".

MINOR

B24EEM41	LINEAR CONTROL SYSTEMS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course provides a foundational understanding of classical control theory, focusing on linear systems. It covers system modeling, time and frequency domain analysis, stability analysis, and compensator design using the transfer function approach.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the role of various control blocks and components in feedback systems. (Cognitive Knowledge Level: Understand)
CO 2	Illustrate various control system components and the time domain responses of the linear systems. (Cognitive Knowledge Level: Understand)
CO 3	Describe the concept of stability analysis in control systems. (Cognitive Knowledge Level: Understand)
CO 4	Apply Root locus technique to assess the performance of linear systems. (Cognitive Knowledge Level: Apply)
CO 5	Develop the frequency domain analysis of the given LTI systems. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	20	20	10
Understand	40	40	40
Apply	40	40	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/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)

Overview of Control Systems

Open-loop and closed-loop systems, feedback-advantages and limitations. Applications of control systems in engineering. Mathematical modeling of systems - mechanical and electromechanical systems, transfer function of LTI systems. Force voltage and force current analogy - block diagram representation - block diagram reduction. Signal flow graph - Mason's gain formula - characteristic equation.

MODULE 2 (9 hours)

Control System Components

DC and AC servo motors – synchro - gyroscope - stepper motor - tachogenerator.

Time-Domain Analysis

Standard test signals: Step, ramp, impulse, and sinusoidal. Transient and steady-state responses of systems. Time-domain specifications: Rise time, delay time, maximum peak overshoot, peak time, settling time, Steady state errors, and error constants. Step responses of first and second order systems.

MODULE 3 (9 hours)

Error Analysis

Steady state error analysis - static error coefficient of type 0, 1, 2 systems - dynamic error coefficients. Concept of stability: definition and types of stability (absolute and relative stability). Stability in time-domain and frequency-domain analysis. Concept of bounded input, bounded output (BIBO) stability. Pole-zero locations and their impact on stability. Routh-Hurwitz stability criterion: formulation and applications. Time response for various pole locations - stability of feedback system.

MODULE 4 (9 hours)

Root Locus Analysis

Introduction to the root locus technique. Definition and significance of root locus in control system design. Rules for constructing root locus: Steps to sketch a root locus manually. System behavior on the root locus-effect of varying system gain K on the root locus. Relation between root locus, transient response, and stability. Movement of poles with gain adjustment and impact on time-domain specifications. Analysis for specific systems-root locus for second-order systems: oscillation and damping analysis. Special cases: Systems with repeated poles, zeros at infinity, or poles at the origin.

MODULE 5 (9 hours)

Introduction to Frequency Domain Analysis

Importance of frequency response in control systems. Frequency response characteristics - Gain, phase, and frequency relationship. Magnitude and phase plots for system transfer functions. Concept of resonance and resonant frequency. Bode plot analysis - construction of Bode magnitude and phase plots. Analysis of gain margin (GM) and phase margin (PM). Correlation between time and frequency response, minimum phase system. Determining system stability using Bode plots. Impact of poles and zeros on Bode plots. Polar plot-Nyquist stability criterion - Nichols chart, Non-minimum phase system (Basic concept only).

Text Books

1. Nagarath I. J. and Gopal M, *Control System Engineering*, New Age Publishers 8th ed., 2025
2. Ogata K, *Modern Control Engineering*, Prentice Hall of India, 5th ed., 2020.
3. Nise N. S., *Control Systems Engineering*, Wiley Eastern, 8th ed., 2020.

Reference Books

1. Gopal M., *Control Systems Principles and Design*, Tata McGraw Hill, 4th ed., 2023.
2. Kuo B. C., *Automatic Control Systems*, Prentice Hall of India, 10th ed., 2017.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Overview of Control Systems	9
1.1	Open-loop and closed-loop systems, Feedback-Advantages and limitations. Applications of control systems in engineering	1
1.2	Mathematical Modeling of Systems- Mechanical and Electromechanical systems	1
1.3	Transfer function of LTI systems	1
1.4	Force voltage and force current analogy	1
1.5	Block diagram representation - block diagram reduction	2
1.6	Signal flow graph - Mason's gain formula - characteristic equation	2
1.7	Transient and steady-state responses of systems	1
	Module 2: Control System Components and Time Domain Analysis	9
2.1	DC and AC servo motors	1
2.2	Synchro, gyroscope	1
2.3	Stepper motor, Tacho generator	1
2.4	Standard test signals: Step, ramp, impulse, and sinusoidal	1
2.5	Transient and steady-state responses of systems	1
2.6	Time-domain specifications: Rise time, peak time, delay time, settling time, maximum peak overshoot	2
2.7	Steady-state errors and error constants	1
2.8	Step responses of first and second order systems	1
	Module 3: Error Analysis	9
3.1	Steady state error analysis	1
3.2	Static error coefficient of type 0, 1, 2 systems	1
3.3	Dynamic error coefficients	1
3.4	Concept of stability: Definition and types of stability (absolute and relative stability)	1
3.5	Stability in time-domain and frequency-domain analysis	1
3.6	Concept of bounded input, bounded output (BIBO) stability	1
3.7	Pole-zero locations and their impact on stability	1
3.8	Routh-Hurwitz stability criterion: Formulation and applications	1
3.9	Time response for various pole locations - stability of feedback system	1
	Module 4: Root Locus Analysis	9
4.1	Definition and significance of root locus in control system design	1

4.2	Rules for constructing root locus: Steps to sketch a root locus manually	2
4.3	System Behavior on the Root Locus-Effect of varying system gain K on the root locus	1
4.4	Relation between root locus, transient response, and stability.	1
4.5	Movement of poles with gain adjustment and impact on time-domain specifications	1
4.6	Analysis for Specific Systems - Root locus for second-order systems: Oscillation and damping analysis	2
4.7	Systems with repeated poles, zeros at infinity, or poles at the origin	1
	Module 5: Introduction to Frequency Domain Analysis	9
5.1	Importance of frequency response in control systems	1
5.2	Frequency Response Characteristics-Gain, phase, and frequency relationship	1
5.3	Magnitude and phase plots for system transfer functions	1
5.4	Concept of resonance and resonant frequency	1
5.5	Bode Plot Analysis - Construction of Bode magnitude and phase plots	1
5.6	Analysis of gain margin (GM) and phase margin (PM)	1
5.7	Correlation between time and frequency response, minimum phase system	1
5.8	Determining system stability using Bode plots. Impact of poles and zeros on Bode plot	1
5.9	Polar plot- Nyquist stability criterion-Nichols chart - Non-minimum phase system	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain how does the feedback element affect the performance of the closed loop system.
2. Summarize how Mason's gain formula can be used to derive the transfer function of a given system.
3. Problems on block diagram reduction.

Course Outcome 2 (CO 2)

1. Show the different time domain specifications for a given second order system with step input.
2. Derive and explain the transfer function of AC servo motor.
3. Problems to calculate error constants.

Course Outcome 3 (CO 3)

1. Problems related to static error constant and steady state error for a given input.
2. Explain how pole locations can alter the stability of the system.
3. Problems related to Routh-Hurwitz stability criterion.

Course Outcome 4 (CO 4)

1. Problems on construction of root locus for different systems.
2. Illustrate how the addition of poles and zeros have an effect on root locus.
3. What is the effect of repeated poles in a system?

Course Outcome 5 (CO 5)

1. Problems on construction of Bode plot for different systems.
2. Problems related to assess the stability of the given system using Bode plot.
3. Explain concept of Nyquist stability criterion.

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: : B24EEM41

Course Name: : LINEAR CONTROL SYSTEMS

Max. Marks: 100

Duration: 3 hours

PART A

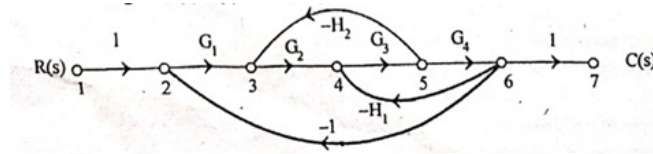
Answer all questions. Each question carries 3 marks.

1. Give a comparison between open loop and closed loop control systems.
2. Explain force-voltage and force-current analogies with one example each.
3. List The different Standard test signals used in the analysis of control systems.
4. For the closed loop system $G(s) = \frac{1}{s(s+5)}$ $H(s) = 0.05$, calculate the steady state error constants
5. Differentiate between absolute and relative stability.
6. How do pole-zero locations affect system stability?
7. What is the root locus technique? State its significance in control system design.
8. With suitable sketches explain how the addition of poles to the open-loop transfer function affect the root locus plots.
9. Explain the features of non-minimum phase systems.
10. Define gain margin and phase margin.

PART B

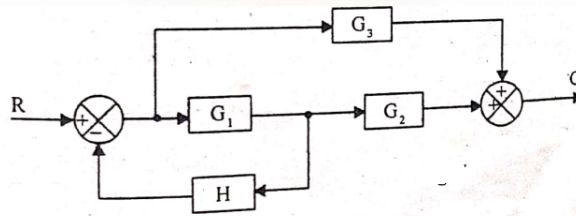
Answer any one question from each module. Each question carries 14 marks.

11. Applying Mason's gain formula, derive the transfer function of the system whose signal flow graph is given below. (14 marks)



OR

12. (a) List the advantages of negative feedback over positive feedback system. (4 marks)
- (b) Reduce the block diagram and hence find out $\frac{C(s)}{R(s)}$. (10 marks)



13. (a) Derive the transfer function of an Armature controlled dc servo motor. Assess the effect of time constants on the system performance. (10 marks)
- (b) Differentiate between Transient and steady-state responses of a second order system. (4 marks)

OR

14. (a) With the help of a neat diagram, define rise time, delay time, peak time, Maximum overshoot and settling time in time-domain specifications of a second order system when excited by a step input. (10 marks)
- (b) A system has the transfer function $\frac{Y(s)}{X(s)} = \frac{50}{s^2 + 10s + 50}$. Determine the damping ratio and natural frequency. (4 marks)
15. (a) Explain how Routh-Hurwitz stability criterion can be used to find out the stability of the system. Also, illustrate how to find out if the system is marginally stable using the Routh criteria. (10 marks)
- (b) Using Routh criterion, determine the value of K for which the unity feedback closed loop system with $G(s) = \frac{K}{s(s^2 + 20s + 8)}$ is stable. (4 marks)

OR

16. (a) Explain steady-state error analysis for type-0, type-1, and type-2 systems. Derive the steady-state error for a unit ramp input for a type-1 system. (10 marks)
- (b)) A type-1 system has the open-loop transfer function $G(s) = \frac{50}{s(s+5)}$. Find the steady-state error for a unit ramp input. (4 marks)
17. (a) Define Angle and Magnitude criteria used in the Root locus method. (4 marks)
- (b) Sketch root locus for a system with $G(s)H(s) = \frac{K(s+1)}{s(s+4)}$. Hence determine the range of K for the system stability. (10 marks)

OR

18. (a) Briefly explain the steps for constructing root locus of a system. (4 marks)
- (b) Sketch the root locus for a system with $G(s)H(s) = \frac{K}{s(s+1)(s+3)}$. (10 marks)
19. (a) What is a Nichols chart used for? (4 marks)
- (b) A system has the transfer function $G(s) = \frac{10}{s(s+2)}$. Construct the Bode magnitude and phase plots and determine the gain margin and phase margin. (10 marks)

OR

20. The open-loop transfer function of the system is given by $G(s) = \frac{50}{s(s+2)(s+5)}$. Construct the Bode magnitude and phase plots and determine the gain margin (GM) and phase margin (PM). (14 marks)

B24EEM42	FUNDAMENTALS OF ELECTRICAL MACHINES	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

The purpose of the course is to provide the concept of electrical machines including construction details, principle of operation and performance analysis. This course provides an overview of DC machines, transformers, synchronous machines and induction machines. After the completion of the course, the students will be able to identify the appropriate electrical machines required for different applications, considering the parameters like input supply voltage, output torque, and speed.

Prerequisites

Basics of Electrical Engineering/Fundamentals of Electrical Engineering.

Course Outcomes

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

CO 1	Analyze the knowledge about constructional details of DC machines. (Cognitive Knowledge Level: Apply)
CO 2	Evaluate the performance of a single phase transformer based on appropriate test results. (Cognitive Knowledge Level: Apply)
CO 3	Analyse the performance of the synchronous motor. (Cognitive Knowledge Level: Apply)
CO 4	Analyse the performance of different types of induction motors. (Cognitive Knowledge Level: Apply)
CO 5	Analyse the performance of single phase and permanent magnet motors which can be used for household applications. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2			1						1
CO 2	3	3		2	2	1					1
CO 3	3	3	1	2	2	1					1
CO 4	3	3	1	2	2	1					1
CO 5	3	3	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	10
Understand	40	40	40
Apply	40	40	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/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 (10 hours)

DC Machines

Principle of operation of DC generator, emf equation, types of excitations - separately excited, shunt and series excited DC generators, compound generators. General idea of armature reaction, open circuit and load characteristics - simple numerical problems. Principles of DC motors, torque and speed equations, torque speed characteristics, characteristics and applications of DC shunt, series, and compound motors. Methods of starting, losses, and efficiency - numerical problems.

MODULE 2 (8 hours)

Transformers

Principle of operation, emf equation, phasor diagram, losses and efficiency, OC and SC tests. Equivalent circuits, efficiency calculations, maximum efficiency - all day efficiency, numerical problems.

MODULE 3 (9 hours)

Synchronous Machines

Parts of synchronous generator, principle of operation, types, emf equation of alternator, regulation of alternator under lagging and leading power factor – determination of regulation by emf method – numerical examples. Principle of operation of synchronous motors, methods of starting, V curves, synchronous condenser.

MODULE 4 (8 hours)

Three-phase Induction Motors

Slip ring and squirrel cage types, principle of operation, rotating magnetic field, equivalent circuit, torque slip characteristics, no load and blocked rotor tests. Methods of starting – direct online, star delta, rotor resistance, and auto transformer starting. Induction generator, principle of operation, self excited induction generators.

MODULE 5 (9 hours)

Single-phase Motors

Principle of operation of single phase induction motor, split phase motor, capacitor start motor. Stepper motor – principle of operation, types. Principle of operation and applications of universal motor and servo motor (DC and AC). Permanent magnet motors - principle of operation of PMSM and PMBLDC motor applications.

Text Books

1. P. S. Bimbhra, *Electrical Machinery*, Khanna Publishers, 7th ed., 2021.
2. D. P. Kothari and I. J. Nagrath, *Electric Machines*, Tata McGraw Hill, 5th ed., 2017.
3. B. L. Theraja , *A Textbook of Electrical Technology*, S. Chand and Company, 2014.

Reference Books

1. A. E. Fitzgerald, C. Kingsley and S. Umans, *Electric Machinery*, McGraw Hill, 6th ed., 2003.
2. Langsdorf M. N., *Theory of Alternating Current Machinery*, Tata McGraw Hill, 2001.
3. Say M. G., *The performance and Design of AC Machines*, CBS Publishers, New Delhi, 2002.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	44 Hours
	Module 1: DC Machines	10
1.1	Principle of operation-emf equation-types of excitations - separately	3
1.2	General idea of armature reaction, OCC and load characteristics - numerical problems	2
1.3	Principles of DC motor-torque and speed equations-torque speed characteristics	2
1.4	Characteristics and applications of DC shunt, series and compound motors. Principles of starting, losses and efficiency - numerical problems	3
	Module 2: Transformers	8
2.1	Principle of operation - emf equation, phasor diagram	2
2.2	Losses and efficiency - OC and SC tests, Equivalent circuit	3
2.3	Efficiency calculations-maximum efficiency-all day efficiency - numerical problems	3
	Module 3: Synchronous Machines	9
3.1	Parts of synchronous generator - principle of operation - types	2
3.2	Emf equation of alternator - regulation of alternator under lagging and leading power factor - numerical problems	2

3.3	Determination of regulation by emf method -numerical examples	2
3.4	Principle of operation of synchronous motors-methods of starting. V-curves-synchronous condenser	3
	Module 4: Three-phase Induction Motors	8
4.1	Slip ring squirrel cage Types - principle of operation-rotating magnetic field	2
4.2	Torque-slip characteristics - no-load and blocked rotor tests, equivalent circuit - numerical problems	3
4.3	Methods of Starting - direct online,star-delta, rotor resistance and autotransformer starting	2
4.4	Induction Generator - principle of operation - self excited induction generators	1
	Module 5: Single-phase Motors	9
5.1	Principle of operation Single Phase Induction Motor – split phase motor - capacitor start motor	2
5.2	Stepper motor - principle operation - types	2
5.3	Universal motor, servo motor - DC and AC servomotors–principle of operation, applications	3
5.4	Permanent magnet motors - principle operation PMSM and PMLDC motor, applications	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Discuss the types of dc generators based on the method of excitation.
2. Discuss the applications of dc motors based on their characteristics.

Course Outcome 2 (CO 2)

1. Draw the phasor diagram of a single phase transformer.
2. Problems based on efficiency calculations, all day efficiency.

Course Outcome 3 (CO 3)

1. Derive the expression for induced emf of alternator.
2. Problems on calculating induced emf of alternator.

3. Why synchronous motor is not self starting? Discuss any two starting methods of synchronous motor?
4. What are V and Inverted V curves?

Course Outcome 4 (CO 4)

1. Explain the working principle of a three-phase induction motor.
2. Why starting current of induction motor is high? Explain any two starting methods.

Course Outcome 5 (CO 5)

1. With the help of a neat diagram explain any two starting methods of single phase induction motor.
2. Discuss the advantages of permanent magnet rotor compared to the conventional construction.
3. Explain the principle of operation of a stepper motor.

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: : B24EEM42

Course Name: : FUNDAMENTALS OF ELECTRICAL MACHINES

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Derive an expression for emf generated in a DC machine.
2. Explain the principle of operation of a DC motor.
3. Draw the phasor diagram of a single-phase transformer working under no load condition.
4. The emf per turn of a single-phase 2200/220 V, 50 Hz transformer is approximately 12 V. Calculate (a) the primary and secondary turns (b) the net cross-sectional area of the core if the maximum flux density is 1.5 Wb/m^2 .
5. How is voltage regulation of an alternator affected by the load connected to its terminals?
6. Why is the synchronous motor not self-starting?
7. Explain torque-slip characteristics of a three-phase induction motor.
8. A three-phase induction motor has 2 poles and is connected to 400 V, 50 supply. Calculate the actual rotor speed and rotor frequency when slip is 4%.
9. Explain the working of a single-phase induction motor.
10. List any three applications of PMBLDC motors.

PART B

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

11. (a) Briefly explain the armature reaction of a DC machine. (5 marks)
(b) Classify DC generators based on their method of excitation with the help of neat diagrams. (9 marks)

OR

12. (a) Explain the power stages of a DC motor. (4 marks)
(b) A 75 kW, 250 V DC compound generator has the following data. $R_a = 0.043 \Omega$, $R_{se} = 0.004 \Omega$, $R_f = 100 \Omega$, Brush contact drop = 1 V/brush. Compare the generated emf when fully loaded for (i) short shunt compound (ii) long shunt compound. (10 marks)
13. (a) Draw the equivalent circuit of a single phase transformer and explain how the parameters are obtained from the test results. (10 marks)
(b) In a 25 kVA, 2000/200 V transformer, the iron and copper losses are 300 W and 400 W respectively. Calculate the efficiency at unity pf at (i) full load (ii) half load. (4 marks)

OR

14. (a) What is all day efficiency? Explain its significance. (4 marks)
(b) A transformer has its maximum efficiency of 0.98 at 20 kVA at unity pf. During the day it is loaded as follows: 12 hours - 2 kW at pf 0.6, 6 hours - 10 kW at pf 0.8, 6 hours - 20 kW at pf 0.9. Find the all day efficiency of the transformer. (10 marks)
15. (a) Explain the constructional details of a synchronous machine. (9 marks)
(b) A 200 kVA, 3.3 kV, 50 Hz, three phase synchronous generator is star connected. The effective armature resistance is $5 \Omega/\text{phase}$ and synchronous reactance is $29.2 \Omega/\text{phase}$. At full load calculate the voltage regulation for 0.8 lagging and 0.8 leading power factors. (5 marks)

OR

16. (a) i. Explain V curves of a synchronous motor. (3 marks)
ii. What is a synchronous condenser? (2 marks)
(b) What is voltage regulation? Explain the method of finding regulation by emf method. (9 marks)
17. (a) Explain the working principle of a three phase induction motor. (5 marks)
(b) Explain the methods of starting of a three phase induction motor. (9 marks)

OR

18. (a) The no load and blocked rotor test results conducted on a 30 hp, 835 rpm, 440V, 3 phase, 60 Hz, squirrel cage induction motor are as follows.
No load test: 440V, 14 A, 1470 W
Blocked rotor test: 163V, 60A, 7200 W.
Resistance measured between two terminals is 0.5Ω . Determine the equivalent circuit parameters. (10 marks)
- (b) What is a self-excited induction generator?. (4 marks)
19. (a) What are the applications of servomotors? (4 marks)
- (b) Explain the different types of stepper motors. (10 marks)

OR

20. (a) What are universal motors? Explain their working. (9 marks)
- (b) Write a short note on permanent magnet motors. (5 marks)

B24EEM43	ENERGY STORAGE SYSTEMS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

The purpose of the course is to introduce the importance and application of energy storage systems. This course provides an overview of different energy storage technologies. After completion of this course students will be able to understand the applications of energy storage technologies.

Prerequisites

Introduction to Power Engineering.

Course Outcomes

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

CO 1	Understand the role of energy storage in power systems. (Cognitive Knowledge Level: Remember)
CO 2	Describe thermal, kinetic and potential storage technologies and their applications. (Cognitive Knowledge Level: Understand)
CO 3	Describe electrochemical, electrostatic and electromagnetic storage technologies. (Cognitive Knowledge Level: Understand)
CO 4	Illustrate energy storage technology in renewable energy integration. (Cognitive Knowledge Level: Understand)
CO 5	Analyse energy storage technology applications for smart grids. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	1	2		1	2			2	2	2
CO 2	3	2		1		2			1		2
CO 3	3	2		1		2			1		2
CO 4	3	2		1		2			1		2
CO 5	3	2			2	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	60	60	40
Apply			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

noindent 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)

Introduction to Energy Storage in Power Systems

Need and role of energy storage systems in power system, general considerations, energy and power balance in a storage unit, mathematical model of storage system: modelling of power transformation system (PTS) - central store (CS) and charge-discharge control system (CDCS), econometric model of storage system.

Storage applications - general considerations, static and dynamic duties of storage plant, storage at the user's level, storage and transport, applications.

MODULE 2 (10 hours)

Energy Storage Technologies I

Thermal energy storage - general considerations, storage media containment, power extraction, thermal energy storage in a power plant, economic evaluation. Flywheel storage - general considerations, flywheel as a central store, applications. Pumped hydro storage - general considerations, power extraction system, central store for pumped hydro. Compressed air energy storage - general considerations basic principles, central store, power extraction system, despatch and economic limitations. Hydrogen and other synthetic fuels - general considerations, synthetic storage media, hydrogen production, storage containment for hydrogen, hydride concept.

MODULE 3 (10 hours)

Energy Storage Technologies II

Electrochemical energy storage - General considerations, Primary vs Secondary batteries, battery parameters- C-rating, SoC, DoD, specific energy, specific power. Fuel cells - schematic diagram of an electrochemical fuel cell, thermal regime, power extraction system. Capacitor bank storage - capacitor storage media, power extraction Superconducting magnetic energy storage - basic principles, superconducting coils, cryogenic systems, power extraction. Considerations on the choice of a storage system - comparison of storage technique.

MODULE 4 (8 hours)

Energy Storage and Renewable Power Sources

Types of renewable energy sources - wave, wind, tidal, small-scale hydroelectric energy, solar thermal technologies and photovoltaics, storage role in isolated power systems with renewable power sources, storage role in an integrated power system with grid connected renewable power sources.

MODULE 5 (8 hours)

Energy Storage Applications

Smart grid, smart microgrid, smart house, field of electromobility - thyristor based battery charger and DC power supply, mobile storage system: Electric vehicles – Grid to Vehicle (G2V)-Vehicle to Grid (V2G), Management and control hierarchy of storage systems- aggregating energy storage systems and distributed generation (virtual power plant energy management with storage systems), battery SCADA, hybrid energy storage systems: configurations and applications.

Text Books

1. A. G. Ter-Gazarian, *Energy Storage for Power Systems*, The Institution of Engineering and Technology (IET) Publication, UK, 2nd ed., 2011.
2. Francisco Díaz-González, Andreas Sumper, Oriol Gomis-Bellmunt, *Energy Storage in Power Systems* Wiley Publication, ISBN: 978-1-118-97130-7, 2016.

Reference Books

1. Electric Power Research Institute (USA), *Electricity Energy Storage Technology Options: A White Paper Primer on Applications, Costs, and Benefits* (1020676), December 2010.
2. Paul Denholm, Erik Ela, Brendan Kirby and Michael Milligan, *The Role of Energy Storage with Renewable Electricity Generation*, National Renewable Energy Laboratory (NREL).
3. P. Nezamabadi and G. B. Gharehpetian, *Electrical energy management of virtual power plants in distribution networks with renewable energy resources and energy storage systems*, IEEE Power Distribution Conference, 2011.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Introduction to Energy Storage in Power Systems	9
1.1	General considerations - different parts of energy storage unit - static duty of storage plant - dynamic duty of storage plant	2
1.2	Energy and power balance in a storage unit- schematic structure of energy storage	1
1.3	Mathematical model of storage system	1
1.4	Econometric model of storage- capital cost of energy storage- annual cost of storage facility	2
1.5	Storage applications - general considerations, static and dynamic duties of storage plant	2
1.6	Storage at the user's level, storage and transport, applications	1
	Module 2: Energy Storage Technologies I	10
2.1	Thermal energy storage - general considerations, storage media containment, power extraction, thermal energy storage in a power plant, economic evaluation	2
2.2	Flywheel storage - general considerations, flywheel as a central store, applications	2
2.3	Pumped hydro storage - general considerations, power extraction system, central store for pumped hydro	2
2.4	Compressed air energy storage - general considerations basic principles, central store, power extraction system, despatch and economic limitations.	2
2.5	Hydrogen and other synthetic fuels - general considerations, synthetic storage media, hydrogen production, storage containment for hydrogen, hydride concept	2
	Module 3: Energy Storage Technologies II	10
3.1	Electrochemical energy storage - General considerations, Primary vs Secondary batteries	2
3.2	Battery parameters- C-rating, SoC, DoD, specific energy, specific power	1
3.3	Fuel cells - schematic diagram of an electrochemical fuel cell, thermal regime, power extraction system	2
3.4	Capacitor bank storage - capacitor storage media, power extraction	2
3.5	Superconducting magnetic energy storage - basic principles, superconducting coils, cryogenic systems, power extraction	2

3.6	Considerations on the choice of a storage system - comparison of storage technique	1
	Module 4: Energy Storage and Renewable Power Sources	8
4.1	Types of renewable power sources - wave, wind, tidal (brief description)	2
4.2	Small scale hydroelectric energy sources	1
4.3	Solar thermal technologies and photovoltaics	2
4.4	Storage role in isolated power system with renewable power	1
4.5	Storage role in an integrated power system with grid-connected renewable power sources	2
	Module 5: Energy Storage Applications	8
5.1	Smart grid, smart microgrid, smart house - concepts, characteristics, smart metering	2
5.2	Field of electromobility - thyristor based battery charger and DC power supply	1
5.3	Mobile storage system: Electric vehicles – Grid to Vehicle (G2V)-Vehicle to Grid (V2G)	1
5.4	Management and control hierarchy of storage systems - aggregating energy storage systems and distributed generation (virtual power plant energy management with storage systems)	2
5.5	Battery SCADA	1
5.6	Hybrid energy storage systems: configurations and applications	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. What are the different parts of a complete energy storage unit?
2. Explain the Dynamic Duty of storage plant.
3. What are the different types of central store?

Course Outcome 2 (CO 2)

1. List the applications of thermal energy storage systems.
2. Explain hydrogen-based power utility concept.
3. What are the different storage containments of hydrogen?

Course Outcome 3 (CO 3)

1. Explain the working of fuel cell along with schematic diagram.
2. Write short notes on supercapacitors.
3. Explain the arrangement of a control and protection system for Super Conducting Magnetic Energy Storage.

Course Outcome 4 (CO 4)

1. Explain small-scale hydroelectric energy.
2. Write short notes on wave energy and its storage system.
3. What are the different types of renewable power sources?

Course Outcome 5 (CO 5)

1. Explain distributed energy storage system.
2. What are the characteristics of smart grid system?
3. What is demand response?

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg. No.:

Name:

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

FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2026

Course Code: : B24EEM43

Course Name: : ENERGY STORAGE SYSTEMS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Discuss the power transformation of energy storage system.
2. Explain the different components of energy storage system with schematic structure.
3. Define Flow equation related to thermal energy storage system.
4. Write the difference between hybrid and combined energy storage in power system.
5. Explain the chemical reaction of lead acid batteries.
6. Write down the basic principle of capacitor bank storage system.
7. Classify hydro power plants based on their rated capacity.
8. Briefly discuss small-scale hydroelectric energy system.
9. What is distributed energy storage system?
10. List the various layers of smart grid.

PART B

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

11. (a) Explain static duty of energy storage plant. (8 marks)
(b) With neat diagram explain energy and power balance in a storage unit. (6 marks)

OR

12. (a) Explain the econometric model of energy storage. Derive the expression for annual cost of the system. (10 marks)
(b) What are the key parameters considered for the comparison of energy storage in power system? (4 marks)
13. (a) Discuss the working principle of compressed air energy storage system. (10 marks)
(b) Write a short note on flywheel energy storage system. (4 marks)

OR

14. (a) Write any three industrial methods to produce hydrogen. (9 marks)
(b) Explain 'power to gas' concept. (5 marks)
15. (a) Explain the working of Li-ion batteries. (7 marks)
(b) Describe the typical voltage–discharge profile for a battery cell. (7 marks)

OR

16. (a) Describe the basic principle and working of superconducting magnetic energy storage system. (7 marks)
(b) With the help of a block diagram, explain the arrangement of control and protection system for superconducting magnetic energy storage system. (7 marks)
17. (a) What are the main features of renewable energy systems? (4 marks)
(b) Explain the role of storage systems in an integrated power system with grid-connected renewable power sources. (10 marks)

OR

18. (a) Explain photovoltaics system. (12 marks)
(b) Discuss the role of storage in an isolated power system with renewable power sources. (2 marks)
19. (a) Describe the distributed energy storage system. (6 marks)
(b) "HEV act as a distributed energy generator and storage", justify your answer. (8 marks)

OR

20. (a) What is demand response? (5 marks)
(b) Draw and explain the battery SCADA system. (9 marks)



HONOURS

B24EEH41	NETWORK ANALYSIS AND SYNTHESIS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	2	0	5		

Preamble

This course aims to provide an in-depth exploration of concepts and techniques beyond the foundational knowledge of electrical circuits and networks. It is designed to deepen knowledge beyond basic circuit analysis, focusing on the intricate behaviors of complex networks and introducing essential concepts in network synthesis and filter design. Its goal is to broaden the student's understanding and skills in both the theoretical and practical aspects of network behavior, enabling them to analyze and design more sophisticated electrical systems.

Prerequisites

Circuits and Networks.

Course Outcomes

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

CO 1	Apply network topology concepts in the formulation and solution of electric network problems. (Cognitive Knowledge Level: Apply)
CO 2	Apply Kirchoff's law and tellegens theorem to formulate and solve network equations involving both independent and dependent sources. (Cognitive Knowledge Level: Apply)
CO 3	Apply two-port network analysis in the design and analysis of filter and attenuator networks. (Cognitive Knowledge Level: Apply)
CO 4	Identify the properties and characteristics of network functions, and verify the mathematical constraints for their physical realisation. (Cognitive Knowledge Level: Understand)
CO 5	Synthesize passive one-port networks using standard Foster and Cauer forms. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	30	30	20
Understand	40	40	50
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 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 (8 hours)

Network Topology

Linear oriented graphs - incidence matrix of a linear oriented graph - Kirchoff's laws in incidence matrix formulation - nodal analysis of networks (independent and dependent sources) - circuit matrix of linear oriented graph - Kirchoff's laws in fundamental circuit matrix formulation.

MODULE 2 (7 hours)

Loop and Nodal Analysis of Electric Networks

Planar graphs - mesh analysis - duality - cut-set matrix - fundamental cut set matrix - relation between circuit, cut-set and incidence matrices - Kirchoff's laws in fundamental cut set formulation - node-pair analysis - analysis using generalized branch model (node, loop and node pair analysis) - Tellegen's theorem.

MODULE 3 (12 hours)

Modeling of Two-port Networks

Modeling of Two-port networks - application examples - amplifiers, transmission lines, passive filters. Review of network parameter sets for two-port networks (z , y , h , g , T parameters, equivalent circuits)(Review may be done using assignments/homework).

Inter-relationship between parameters, Image parameter description of a reciprocal two-port network - Image impedance - characteristic impedance - propagation constant - derivation of characteristic impedance and propagation constant for T and Π networks under sinusoidal steady state - Attenuation constant and phase constant. Filter terminology: Low pass, high pass, band-pass and band-reject filters. Constant k and m -derived filters - low pass, high pass, band-pass and band-stop filters - design - effect of cascading multiple sections. Resistive T , Π , and lattice attenuators.

MODULE 4 (10 hours)

Network Functions

Network functions for one-port and two port networks - pole zero location for driving point and transfer functions - Impulse response of network functions from pole-zero plots - sinusoidal steady-state frequency response from pole-zero plots. Hurwitz polynomials - properties - Positive real functions - properties of positive real functions - passivity - necessary and sufficient conditions for positive real functions - physical realizability.

MODULE 5 (8 hours)

Synthesis of One Port Networks

Synthesis of reactive one-ports by Foster's and Cauer methods (forms I and II) - synthesis of LC, RC and RL driving point functions.

Text Books

1. K. S. Suresh Kumar, *Electric Circuit Analysis*, Pearson Education, 2nd ed., 2022.
2. Ravish R. Singh, *Network Analysis and Synthesis*, McGraw-Hill Education, 2013.
3. S. K. Bhattacharya, *Network Analysis and Synthesis*, Pearson Publications, 2013.
4. Chakrabarti, A, *Circuit Theory Analysis and Synthesis*, Dhanpat Rai Co., 7th - Revised ed., 2018.

Reference Books

1. Van Valkenburg M.E, *Introduction to Modern Network Synthesis*, Wiley Eastern.
2. Van Valkenburg M.E, *Network Analysis*, Prentice Hall India, 2014.
3. Charles A. Desoer and Ernest S. Kuh, *Basic Circuit Theory*, Tata McGraw-Hill, 10th ed., 2023.
4. William H. Hayt and Jack E. Kemmerly, *Engineering Circuit Analysis*, McGraw-Hill Education 8th ed., 2013.
5. Richard C. Dorf and James A. Svoboda, *Introduction to Electric Circuits*, Wiley, 9th ed., 2013.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Network Topology	8
1.1	Linear Oriented Graphs - Connected Graph, sub graphs, paths, incidence matrix of a linear oriented graph - Path matrix, its relation to incidence matrix	2
1.2	Kirchoff's Laws in incidence matrix formulation - nodal analysis of networks (independent and dependent sources), principle of v-shifting	2
1.3	Circuit matrix of linear oriented graph - Fundamental Circuit matrix Bf. Relation between All incidence matrix and All Circuit matrix	2
1.4	Kirchoff's laws in fundamental circuit matrix formulation	2
	Module 2: Loop and Nodal Analysis of Electric Networks	7
2.1	Loop analysis of electric networks (with independent and dependent sources) - Planar graphs - Mesh analysis - Duality	2
2.2	Cut set matrix - Fundamental cut set matrix - Relation between circuit, cut set and incidence matrices - Orthogonality relation	2
2.3	Kirchoff's laws in fundamental cut-set formulation - Node-pair analysis, i-shifting	2
2.4	Analysis using generalized branch model (node, loop and node pair analysis) - Tellegen's theorem	1
	Module 3: Modeling of Two-port Networks	12
3.1	Modeling of Two-port networks - application examples-amplifiers, transmission lines, passive filters. Review of network parameter sets for two-port networks (z, y, h, g, T parameters, equivalent circuits, Standard T - and pi networks) (Review may be done using assignments/home-work). Interrelationship between parameters	2
3.2	Image parameter description of a reciprocal two-port network - Image impedance	1
3.3	Characteristic impedance - propagation constant—derivation of characteristic impedance and propagation constant for T and Pi networks under sinusoidal steady state – Attenuation constant and phase constant	2
3.4	Filter terminology: Low pass, high pass, band-pass and band-reject filters. Gain characteristics. Constant k-derived low pass filter - Comparison with ideal low-pass filter - Prototype Low pass filter design	2

3.5	m-derived low pass filter sections, m-derived half-sections for filter termination. m-derived half-sections for input termination. Half-pi termination for pi section filters	2
3.6	Constant k- and m-derived high pass filters -Design. Constant k - band-pass filter - Design of prototype bandpass filter – Constant-k band-stop filter -effect of cascading multiple sections	2
3.7	Resistive attenuators - Symmetric T and Pi section attenuators - Lattice-section attenuator - Symmetrical bridged T-section attenuator - Asymmetrical T-Section and Pi-section attenuator	1
Module 4: Network Functions		10
4.1	Network functions for one-port and two-port networks - calculation of network functions for ladder and general networks	2
4.2	poles and zeros for network functions - pole-zero location for driving point and transfer functions	2
4.3	Impulse response of Network functions from pole-zero plots - Sinusoidal steady-state frequency response from pole-zero plots	2
4.4	Hurwitz polynomials - properties - Positive real functions - Properties of positive real functions - passivity	2
4.5	Necessary and sufficient conditions for positive real functions - physical realizability	2
Module 5: Synthesis of One Port Networks		8
5.1	Synthesis of reactive one-ports by Foster's and Cauer methods (forms I and II): Synthesis of R–C Network - Properties of the R–C Impedance or R–L Admittance Function	2
5.2	Foster Form-I of RC Network - Foster Form-II of RC Network, Cauer Forms of RC Network	2
5.3	Synthesis of RL Network - Properties of RL Function/RC Admittance Function - Foster Form-I of RL Network	1
5.4	Foster Form-II of RL Network - Cauer Form-I of RL Network - Cauer Form-II RL Network	1
5.5	Synthesis of LC Networks - Properties of LC Immittance - Foster Form-I of LC Network	1
5.6	Foster Form-II of LC Network - Cauer Form-I of LC Network - Cauer Form-II of LC Network	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Questions on Network topology terminology, definitions.
2. Questions on identification of graphs, paths, sub-paths, etc and on incidence matrix.

3. Numerical problems on application of Kirchoff's laws in matrix formulation, nodal analysis.

Course Outcome 2 (CO 2)

1. Numerical problems on graph theory-based network analysis, cut-set, circuit matrices, nodal and loop analysis.
2. Questions on loop analysis of electric networks, cut-set formulation.
3. Questions on analysis of networks using generalized branch model using Tellegen's theorem.

Course Outcome 3 (CO 3)

1. Questions on modelling two-port networks, characteristics impedance and propagation constants.
2. Questions on definitions and properties of filters.
3. Numerical problems on constant-k and m-derived filter design and analysis.

Course Outcome 4 (CO 4)

1. Questions on the properties of network functions and realizability of passive impedance functions.
2. Questions on impulse response of network functions and properties of Hurwitz polynomials.
3. Numerical problems on the realizability of network functions, testing of positive real functions and Hurwitz polynomials.

Course Outcome 5 (CO 5)

1. Questions to describe synthesis of one-ports by Foster and Cauer forms for R-C and R-L networks.
2. Questions to describe the properties of immittance functions.
3. Numerical problems to synthesise networks in Foster and Cauer forms.

MODEL QUESTION PAPER

QP CODE:

Pages: 4

Reg. No.:

Name:

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

FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2026

Course Code: : B24EEH41

Course Name: : NETWORK ANALYSIS AND SYNTHESIS

Max. Marks: 100

Duration: 3 hours

PART A

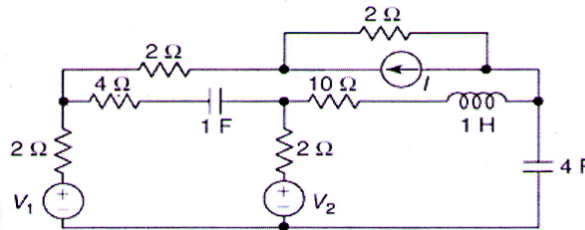
Answer all questions. Each question carries 3 marks.

1. What are the properties of incidence matrix associated with graph theory?
2. Describe the properties of the complete incidence matrix.
3. What are dual graphs? What is the condition for a network graph to have a dual? Illustrate with an example.
4. Describe a cut-set with an example.
5. What is propagation constant? Obtain the propagation constant of r network.
6. Draw the frequency response curves for ideal and non-ideal low pass filter, band pass filter, band reject filter, and high pass filter respectively.
7. Explain what is meant by poles and zeros of a network function.
8. List the properties of positive real functions.
9. What are the properties of LC immittance functions?
10. What is the network interpretation of removal of a pole at origin for an impedance function?

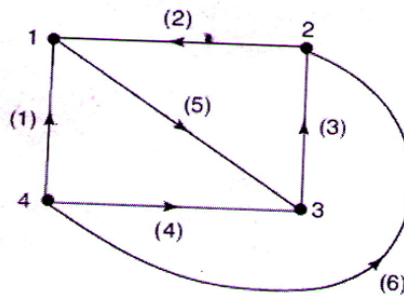
PART B

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

11. (a) For the network shown in figure, draw the oriented graph and write the incidence matrix, reduced incidence matrix and tie set matrix. (7 marks)

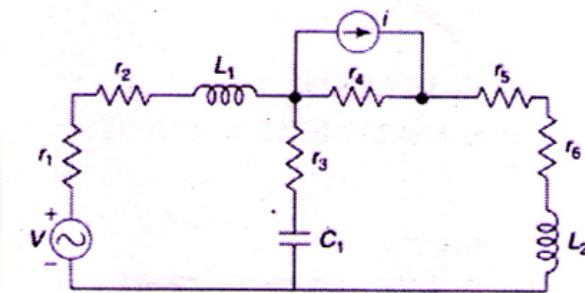


- (b) For the given graph shown in figure, taking a tree of branches 2, 4, 5 write down the tieset matrix and KVL equations. (7 marks)

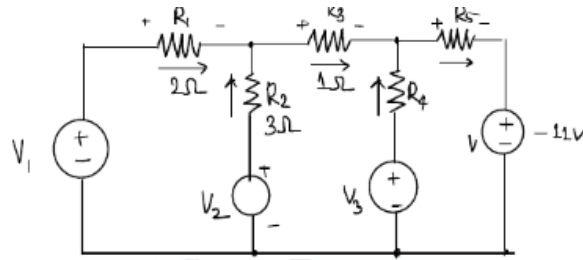


OR

12. (a) State and express Kirchoff's Voltage law in topological form. (4 marks)
 (b) For the circuit shown in figure. Draw the oriented graph and write (a) incidence matrix and (b) tie-set matrix. (10 marks)



13. (a) Find the power delivered by the independent voltage sources in the network shown in figure above by loop analysis (use graph theory). Prepare the network graph using the reference directions marked in the figure. (7 marks)



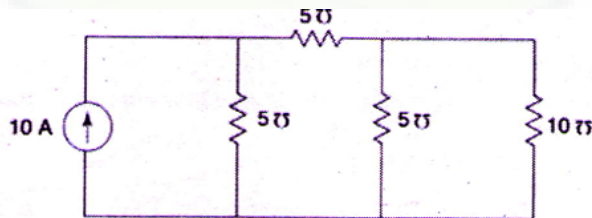
- (b) A connected network has the fundamental circuit matrix given as for some choice of tree. Obtain the f-cut-set matrix for the same tree. (7 marks)

$$Bf = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & -1 & 0 & 0 & 1 & 0 \\ 1 & -1 & -1 & 0 & 0 & 1 \end{bmatrix}$$

OR

14. For the network shown in figure, obtain equilibrium equation on node basis.

(14 marks)



15. (a) Obtain the characteristic impedance of a T network. (8 marks)
 (b) The ABCD parameters of a network are given as $A = \frac{6}{5}$, $B = \frac{17}{5}$, $C = \frac{1}{5}$, $D = \frac{7}{5}$. Find the image parameters and propagation constant. (6 marks)

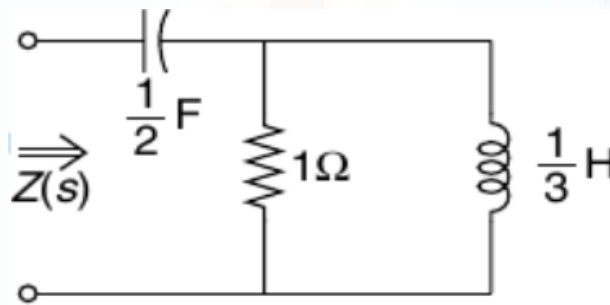
OR

16. (a) Design an m-derived T-section low pass filter having cut off frequency of 1500 Hz, design impedance of 500 ohms and infinite attenuation frequency of 2000 Hz (8 marks)
 (b) Express image parameters in terms of ABCD parameters. (6 marks)

17. (a) Test the following polynomials for the Hurwitz property. (10 marks)
- i. $S^3 + S^2 + 2S + 2$
 - ii. $S^7 + S^5 + S^3 + S$
 - iii. $S^7 + 2S^6 + 2S^5 + S^4 + 4S^3 + 8S^2 + 8S + 4$
- (b) List out the properties of positive real function. (4 marks)

OR

18. (a) Find the limits of K so that the polynomial $s^3 + 14s^2 + 56s + K$ may be Hurwitz. (6 marks)
- (b) Find the driving point impedance $Z(s)$ in the form $K \frac{N(s)}{D(s)}$ for the network shown. Verify that $Z(s)$ is positive real and that the polynomial $D(s) + KN(s)$ is Hurwitz. (8 marks)



19. Realize following RL impedance function in Foster-I and Foster-II form. (14 marks)

$$\frac{Z(s)}{S} = \frac{(S+1)(S+4)}{S(S+5)(S+3)}$$

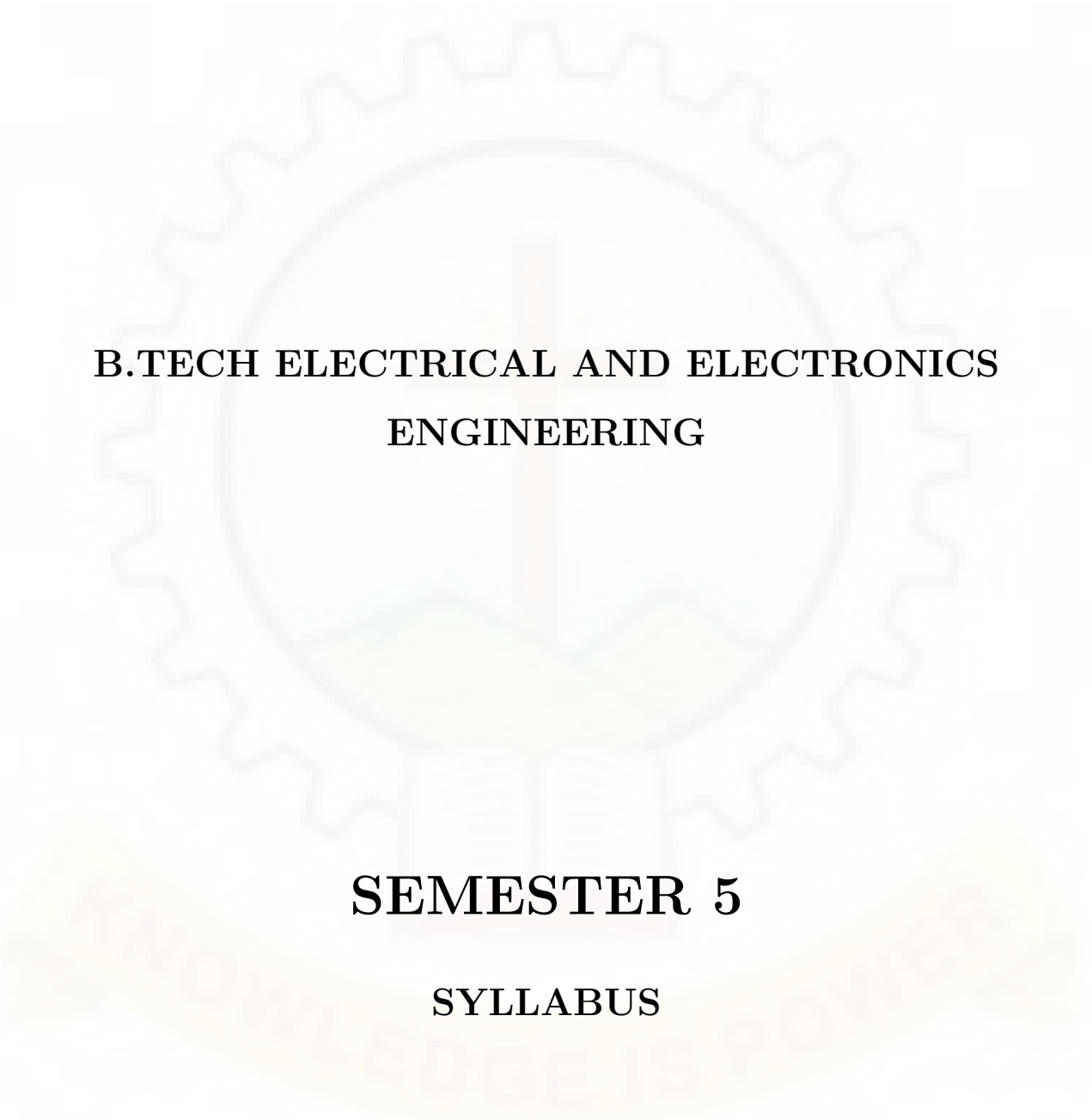
OR

20. (a) Check whether the driving point impedance $Z(s) = \frac{S^3 + S^2 + 1}{S^3 + 2S^2 - 2S + 10}$ represents a passive network or not. (4 marks)
- (b) For the network function $Y(S) = \frac{2(S+1)(S+3)}{(S+2)(S+4)}$, synthesis a Foster form and a Cauer form realisation. (10 marks)

MAR ATHANASIOUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution

Kothamangalam, Kerala, India



**B.TECH ELECTRICAL AND ELECTRONICS
ENGINEERING**

SEMESTER 5

SYLLABUS

SEMESTER 5

SLOT	COURSE NO.	COURSES	L-T-P-S	HOURS	CREDIT
4	B24EE3T01	LINEAR CONTROL SYSTEM	2-2-0-5	4	4
B	B24EE3T02	POWER SYSTEM I	2-2-0-5	4	4
C	B24EE3T03	ELECTRICAL MACHINES II	2-2-0-5	4	4
D	B24EE3T04	INSTRUMENTATION SYSTEMS	3-1-0-5	4	4
E	B24HU3T05	ENTREPRENEURSHIP DEVELOPMENT AND MANAGEMENT STRATEGIES	2-1-0-4	3	3
F	B24EE3P1X	PROGRAMME ELECTIVE I	2-1-0-4	3	3
G	B24EE3L07	MICROPROCESSOR AND MICROCONTROLLER LAB	0-0-3-2	3	2
H	B24EE3L08	POWER ELECTRONICS LAB	0-0-3-2	3	2
M	B24EEM5X	MINOR	3-1-0-5	4	4
N	B24EEH5X	HONOURS	3-1-0-5	4	4
TOTAL				36	26

PROGRAMME ELECTIVE I

COURSE NO.	COURSES
B24EE3P11	BIOMEDICAL INSTRUMENTATION
B24EE3P12	RENEWABLE ENERGY SYSTEMS AND APPLICATIONS
B24EE3P13	HIGH VOLTAGE ENGINEERING
B24EE3P14	MICROCONTROLLERS FOR EMBEDDED SYSTEM DESIGN
B24EE3P15	ELECTRONIC MATERIALS
B24EE3P16	COMPUTER ORGANIZATION AND ARCHITECTURE

MINOR

COURSE NO.	COURSES
BASKET 1	
B24EEM51	SYSTEMS THEORY
BASKET 2	
B24EEM52	SOLID STATE POWER CONVERSION
BASKET 3	
B24EEM53	POWER SYSTEM OPERATION AND CONTROL

HONOURS

COURSE NO.	COURSES
BASKET 1	
B24EEH51	SIMULATION OF ELECTRIC SYSTEMS
BASKET 2	
B24EEH51	SIMULATION OF ELECTRIC SYSTEMS
BASKET 3	
B24EEH51	SIMULATION OF ELECTRIC SYSTEMS

B24EE3T01	LINEAR CONTROL SYSTEM	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	2	0	5	4	2024

Preamble

The aim of this course is to provide a strong foundation in the principles and techniques of classical control systems. It covers time-domain and frequency-domain analysis methods, stability criteria, and the design of controllers and compensators, with supporting simulations using MATLAB/Simulink. By the end of the course, students will be able to analyse system behaviour, evaluate stability, and design suitable control strategies for engineering applications.

Prerequisites

Ordinary Differential Equations and Transforms, Signals and Systems

Course Outcomes

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

CO 1	Develop feedback control systems using the transfer function approach and explain the operation of controllers and phase compensators. (Cognitive Knowledge Level: Understand)
CO 2	Analyse the transient and steady-state responses of first and second-order linear systems to standard test inputs, and determine its time-domain specifications and steady-state errors. (Cognitive Knowledge Level: Apply)
CO 3	Apply Routh–Hurwitz and root locus methods to analyse the stability of linear time invariant systems. (Cognitive Knowledge Level: Apply)
CO 4	Understand the frequency-domain specifications and analyse the frequency response using Bode, polar, and Nyquist plots to determine the stability of the systems. (Cognitive Knowledge Level: Apply)
CO 5	Design lag and lead compensators using Bode plot and root locus techniques and tune PID controllers using Ziegler–Nichols methods. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	20	20	20
Understand	50	30	30
Apply	30	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/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 (8 hours)

Modelling and Control System Components

Open loop and closed loop systems, significance of feedback control systems, examples, transfer function approach to feedback control systems, effect of feedback, transfer function of DC and AC servomotor, applications of synchro, tachogenerator.

Controllers - control action of P, PI, PD, PID controllers. Compensators - basic characteristics of lag, lead, lag-lead phase compensators, transfer function.

MODULE 2 (9 hours)

Time Domain Analysis

Transient response analysis - impulse, step, ramp, parabolic input response of first order systems, second order system - step response of undamped, critically damped, underdamped and overdamped systems. Transient step response specifications - delay time, rise time, peak time, peak overshoot, settling time. Error analysis - steady state error, error constants, dynamic error coefficients.

MODULE 3 (8 hours)

Stability Analysis and Root Locus

Concept of stability of LTI systems - BIBO stability, characteristic equation, pole location, effect of feedback on closed loop stability, Hurwitz polynomial - Routh-Hurwitz criterion. Root locus - construction of root locus, stability analysis, open loop gain for a specified damping of the dominant roots, effect of addition of poles and zeros, impact of positive feedback on root locus.

Use simulation software like MATLAB/SIMULINK for Root locus analysis (Tutorial/Assignment only).

MODULE 4 (12 hours)

Frequency Domain Analysis

Sinusoidal transfer function, frequency response, frequency domain specifications - derivations of resonant peak, resonant frequency and bandwidth, correlation with time domain specifications - peak resonance, and resonant frequency. Bode plot, polar plot, Nyquist plot for stability analysis - construction, gain margin, and phase margin, relative stability, Nyquist stability criteria.

Use simulation software like MATLAB/SIMULINK for Bode plot analysis (Tutorial/Assignment only).

MODULE 5 (8 hours)

Design of Controllers and Compensators

Lag, lead compensator design using Bode plot and root locus technique. Ziegler-Nichols' first and second methods for tuning PID controllers.

Text Books

1. Katsuhiko Ogata, *Modern Control Engineering*, Pearson, 5th ed., 2015.
2. Norman S. Nise, *Control Systems Engineering*, Wiley, 8th ed., 2019.
3. Richard C. Dorf and Robert H. Bishop, *Modern Control Systems*, Pearson, 14th ed., 2021.
4. I.J. Nagrath and M. Gopal, *Control Systems Engineering*, New Age International Publishers, 6th ed., 2022.

Reference Books

1. M. Gopal, *Control Systems: Principles and Design*, McGraw Hill Education, 4th ed., 2012.
2. S. Palani, *Automatic Control Systems with MATLAB*, Springer, 2nd ed., 2022.
3. Benjamin C. Kuo and Farid Golnaraghi, *Automatic Control Systems*, Wiley, 10th ed., 2017
4. Uday A. Bakshi and A.P. Godse, *Control System Theory*, Technical Publications, Revised Edition, 2020.
5. Arun K. Ghosh and Rumi Ghosh, *Introduction to Control Systems*, PHI Learning, 3rd ed., 2023.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Modelling and Control System Components	8
1.1	Open loop and closed-loop systems, significance of feedback control systems, examples	2

1.2	Transfer function approach to feedback control systems, effect of feedback	1
1.3	Transfer function of DC and AC servomotor	2
1.4	Applications of synchro, tachogenerator	1
1.5	Controllers- Control action of P, PI and PID controllers	1
1.6	Compensators- Transfer function and basic characteristics of lag, lead, lag-lead compensators	1
	Module 2: Time domain analysis	9
2.1	Transient response analysis of first order systems- impulse, step, ramp and parabolic input response	2
2.2	Transient response analysis of second order systems-step response of undamped and critically damped systems	2
2.3	Step response of underdamped and overdamped systems	1
2.4	Transient response specifications- derivations of delay time, rise time, peak time, peak overshoot, settling time	2
2.5	Steady state error and error constants- positional, velocity and acceleration error constants	1
2.6	Dynamic error coefficients- correlation between dynamic and static error coefficients	1
	Module 3: Stability Analysis and Root Locus	8
3.1	Concept of stability of LTI systems, BIBO stability	1
3.2	Characteristic equation, pole location, effect of feedback on closed loop stability	1
3.3	Hurwitz polynomial, Routh-Hurwitz Criterion - stability evaluation using Routh Array	1
3.4	Root Locus method-construction of root Locus	2
3.5	Stability analysis- range of values of gain K, relative stability	1
3.6	Determination of open loop gain for a specified damping of the dominant roots	1
3.7	Effect of addition of poles and zeros, impact of positive feedback on root locus	1
	Module 4: Frequency Domain Analysis	12
4.1	Sinusoidal transfer function, frequency response, frequency domain specifications-resonant peak, resonant frequency, bandwidth, cut-off rate	1
4.2	Gain Margin, phase margin, derivation of resonant peak	1
4.3	Derivations of resonant frequency and bandwidth	1
4.4	Correlation with time domain specifications - peak resonance and resonant frequency	1
4.5	Bode plot - construction	2
4.6	Bode plot - gain margin and phase margin, stability analysis	2
4.7	Polar plot- construction	1
4.8	Polar plot- gain margin and phase margin, stability analysis	1
4.9	Nyquist plot- construction, gain margin and phase margin	1

4.10	Stability analysis – Nyquist stability criteria	1
	Module 5: Design of Controllers and Compensators	8
5.1	Lag compensator design using frequency domain technique	2
5.2	Lead compensator design using frequency domain technique	2
5.3	Lag compensator design using root locus technique	2
5.4	Lead compensator design using root locus technique	1
5.5	Ziegler-Nichols first and second method for tuning PID controller	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the construction, principle of operation, and applications of synchros, AC servomotors, and tachometers in control systems.
2. Derive the transfer functions of lag, lead, and lag-lead compensators.
3. Compare open-loop and closed-loop control systems with suitable examples.

Course Outcome 2 (CO 2)

1. Analyse the impulse and step response of a first-order system and determine its time constant and steady-state value.
2. For a second-order underdamped system, analyse the step response and determine rise time, peak time, peak overshoot, and settling time.
3. Given the transfer function of a unity feedback system, analyse its steady-state error for step, ramp, and parabolic inputs using error constants.

Course Outcome 3 (CO 3)

1. Determine the range of system gain for stability and analyse the effect of gain variation using Routh array.
2. Construct the root locus of a given open-loop transfer function and analyse system stability.
3. Analyse the locations of dominant closed-loop poles using root locus method.

Course Outcome 4 (CO 4)

1. Derive and analyse resonant peak, resonant frequency, and bandwidth for a second-order system.
2. Construct the Bode plot of a given system and analyse gain margin and phase margin.
3. Analyse system stability using Nyquist stability criterion for a given transfer function.

Course Outcome 5 (CO 5)

1. Design a lead compensator using root locus technique to meet given transient response specifications and analyse its effect.
2. Design a lead compensator using frequency domain technique to improve phase margin and analyse its effectiveness.
3. Analyse the tuning of PID controller using Ziegler–Nichols first method for a given system.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS),
KOTHAMANGALAM

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: : B24EE3T01

Course Name: : LINEAR CONTROL SYSTEM

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Construct the block diagram of the antenna position control scheme.
2. Derive the transfer function of a phase lead compensator.
3. Evaluate the maximum overshoot and the corresponding peak time for a unity feedback system with open loop transfer function $G(s) = \frac{0.4s+1}{s(s+0.6)}$ with a unit step input signal.
4. For the given open loop transfer function $G(S) = \frac{K}{s(ST+1)}$ for a unity feedback system, find K for which the steady state error is less than 10% when a step input is applied.
5. Explain the effect of the addition of poles and zeros to the root locus.
6. Find the value of K and frequency of sustained oscillations for the unity feedback system whose open loop transfer function is $G(s) = \frac{K}{s(s+2)(s+4)}$.
7. Explain any three frequency domain specifications.
8. Construct the frequency response of magnitude and angle plot of a first-order factor in the denominator.
9. Explain Ziegler Nichols' closed-loop method of tuning the PID controllers.
10. Explain the basic steps in a lag compensator design using Root locus technique.

PART B

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

11. Elaborate on the control application of Synchro as an error detector. (14 marks)

OR

12. Realize the phase lag-lead compensator using suitable electrical network and derive its transfer function. Draw the pole-zero plot for the lag-lead compensator.

(14 marks)

13. For the given open loop transfer function $G(s) = \frac{\omega_n^2}{s(s+2\delta\omega_n)}$ obtain rise time, peak time, peak overshoot and settling time when the system is subjected to a unit step signal. Given the damping ratio as 0.6 and natural frequency as 5 rad/sec.

(14 marks)

OR

14. (a) Develop an expression for the unit step response of a critically damped second-order system.

(5 marks)

- (b) Find the unit step response of a unity negative feedback control system whose open loop transfer function is $G(s) = \frac{4}{s(s+5)}$.

(9 marks)

15. Draw the root locus for the unity negative feedback system with an open loop transfer function $G(s) = \frac{K}{s(s^2+4s+13)}$.

(14 marks)

OR

16. Sketch the root locus for the unity feed back system whose open loop transfer function is $G(s) = \frac{K}{s(s+2)(s+4)}$. Find the value of K at the breakaway point. Also, find the value of K so that the damping ratio is 0.5.

(14 marks)

17. Sketch the Bode plot of the following transfer function $G(s) = \frac{10}{s(1+0.4s)(1+0.1s)}$. Determine the gain crossover frequency and phase crossover frequency.

(14 marks)

OR

18. Draw Nyquist plot for the system $G(s) = \frac{K}{s(s+2)(s+10)}$. Determine the range of K for which the system is stable.

(14 marks)

19. Consider a unity feedback system with an open loop transfer function $G(s) = \frac{K}{s(s+8)}$. Design a lead compensator to meet the following specifications. (i) Percentage peak overshoot=9.5%. (ii) Natural frequency of oscillation = 12 rad/sec. (iii) The velocity error constant ≥ 10 .

(14 marks)

OR

20. A Unity feed back system has an OLTF $G(s) = \frac{K}{s(1+2s)}$. Design a suitable lag compensator so that the phase margin is 40° and the steady state error for ramp input is less than or equal to 0.2.

(14 marks)

B24EE3T02	POWER SYSTEM I	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	2	0	5	4	2024

Preamble

This course aims to give students a comprehensive understanding of power generation, transmission, and distribution systems, focusing on various conventional and modern technologies. It provides an overview of key topics such as generation from renewable and non-renewable sources, the economics of power generation, transmission system design, AC and DC distribution systems and the introduction to energy markets. Upon successful completion, students will gain a solid foundation in power generation technologies, electrical transmission, protection and distribution systems, equipping them with the skills to analyze, design, and optimize electrical power systems efficiently.

Prerequisites

Circuits and Networks

Course Outcomes

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

CO 1	Understand different types of power generation sources and energy storage technologies, including environmental, ethical, and regulatory aspects, and evaluate generation economics using load curves and performance indices. (Cognitive Knowledge Level: Understand)
CO 2	Design electrical parameters of transmission lines and evaluate the performance of short, medium, and long transmission lines using ABCD parameters. (Cognitive Knowledge Level: Apply)
CO 3	Analyze the mechanical characteristics of power transmission, including sag-tension, insulators, corona effects, underground cables, and modern transmission technologies - EHVAC, HVDC, FACTS. (Cognitive Knowledge Level: Apply)
CO 4	Analyze the principles of power system protection and switchgear, including protective relays and circuit breakers, for reliable fault detection and isolation. (Cognitive Knowledge Level: Apply)
CO 5	Understand different types of AC distribution systems, tariff and energy markets. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	1		2	1				2
CO 2	3	2	2	1							2
CO 3	3	2	2	1		2	1				2
CO 4	3	2	2	1			1				2
CO 5	3	2	1	1		2	1				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/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)

Power Generation Sources

Hydro, thermal, nuclear, solar, and wind - block schematic details, environmental and ethical factors, advantages, and disadvantages, regulations for PV systems in India. Energy storage systems - necessity of energy storage, energy storage methods - Battery Energy Storage Systems (BESS), Thermal Energy Storage (TES), Mechanical Energy Storage (MES), pumped hydro - types and applications.

Economics of Generation

Load curve – load duration curve, load factor, diversity factor, demand factor, plant capacity factor, plant use factor - numerical Problems.

MODULE 2 (10 hours)

Performance of Transmission Lines

Line parameters: Resistance, inductance, and capacitance - single phase and three phase circuits for both single circuit and double circuit arrangements, numerical problems, skin effect, Ferranti effect. Transmission line modelling: classifications - short, medium and long transmission lines, two-port network - ABCD parameters, numerical problems.

MODULE 3 (9 hours)

Power Transmission - Physical Aspects

Sag and tension - supports at equal and unequal levels, effect of ice and wind loading, numerical problems, stringing chart. Insulators - string efficiency, grading, numerical problems Corona - factors affecting corona, critical disruptive voltage, visual critical voltage, methods of reducing corona effect. Introduction to EHVAC, HVDC and FACTS - principles, advantages, disadvantages. Underground cables - classification, capacitance of cables, grading of cables - capacitance grading, intersheath grading.

MODULE 4 (9 hours)

Switchgear and Protection

Need for protection, zones of protection, primary and back-up protection. Protective relays: electromechanical relay - induction type, static relay - block diagrams of o/c relays, block diagram and flow chart of microprocessor-based o/c relay, fundamentals of numerical relay, distance relay - impedance relay, differential relay - Buchholz relay, directional relay.

Circuit breakers - introduction, fault clearing time of a circuit breaker, arc voltage, arc interruption, restriking voltage, recovery voltage, resistance switching, current chopping, interruption of capacitive current, classification - SF6 circuit breakers, vacuum circuit breakers.

MODULE 5 (8 hours)

Power Distribution Systems

Distribution system classifications, AC distribution systems - connection schemes - radial and ring main systems, types of AC distributors, power factor referred to sending end voltage, power factor referred to respective load voltage (single phase only), method of power factor improvement using capacitors, tariff - different types, numerical problems. Introduction to energy markets - regulated and deregulated systems.

Text Books

1. C. L. Wadhwa, *Electrical Power system*, New Age International Publishers, 8th ed., 2023.
2. V. K. Mehta, Rohit Mehta, *Principles of Power System*, S. Chand, 4th ed. Reprint 2020.
3. Badri Raman, D. N. Viswakarma, *Power System Protection and Switchgear*, Tata McGraw Hill, 2nd ed., 2011.
4. B. H. Khan, *Non-conventional Energy Sources*, Tata McGraw Hill, 3rd ed., 2017.

Reference Books

1. A. Chakrabarti, M. L. Soni, P. V. Gupta, V. S. Bhatnagar, *A text book of Power system Engineering*, Dhanpat Rai, 2000.
2. Grainer J. J, Stevenson W. D., *Power system Analysis*, McGraw Hill Education, 1st ed., 2017.
3. Stuart Borlase, *Smart Grids, Infrastructure, Technology and Solutions*, CRC Press, 2013.
4. S. Pabla, *Electric Power Distribution*, Tata McGraw Hill Publication, 7th ed., 2019.
5. Uppal S. L., S. Rao, *Electrical Power Systems*, Khanna Publishers, 19th reprint, 2024.
6. D. P. Kothari and I. Nagrath, *Power System Engineering*, Tata McGraw Hills, 3rd ed., 2019.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Power Generation Sources	9
1.1	Hydroelectric, thermal and nuclear power plant- block schematic details, special features, environmental and ethical factors, advantages, disadvantages	2
1.2	Solar, and wind power plant -block schematic details, special features, environmental and ethical factors, advantages, disadvantages, regulations for PV systems in India	2
1.3	Energy storage systems - necessity of energy storage, energy storage methods - Battery Energy Storage Systems (BESS)	1
1.4	Thermal Energy Storage (TES), Mechanical Energy Storage (MES), pumped hydro - types and applications	1
	Economics of Generation	
1.5	Load curve - load duration curve	1
1.6	Load factor, diversity factor, demand factor, plant capacity factor, plant use factor, numerical problems	2
	Module 2: Performance of Transmission Lines	10
2.1	Line parameters: Resistance, inductance, and capacitance - inductance of a single phase transmission line	1
2.2	Inductance of a three phase transmission line	1
2.3	Double circuit arrangements, numerical problems	1
2.4	Capacitance of a single phase and three phase transmission line neglecting the effect of earth, numerical problems	2
2.5	Skin effect, Ferranti effect. Transmission line modelling: classifications - short, medium and long transmission lines, two-port network - ABCD parameters	1
2.6	Modelling of short transmission lines ,numerical problems	1
2.7	Modelling of medium transmission lines - Nominal T and pi methods, numerical problems	2
2.8	Modelling of long transmission lines, numerical problems	1
	Module 3: Power Transmission - Physical Aspects	9
3.1	Sag and tension - supports at equal and unequal levels	1
3.2	Effect of ice and wind loading, numerical problems, stringing chart	1
3.3	Insulators - string efficiency	1
3.4	Grading, numerical problems	1
3.5	Corona - factors affecting corona, critical disruptive voltage, visual critical voltage, methods of reducing corona effect	1
3.6	Introduction to EHVAC, HVDC and FACTS - principles, advantages, and disadvantages	1

3.7	Underground cables - classification, capacitance of cables	1
3.8	Grading of cables - capacitance grading, intersheath grading	2
	Module 4: Switchgear and Protection	9
4.1	Need for protection, zones of protection, primary and back-up protection	1
4.2	Protective relays: electromechanical relay - induction type, static relay	1
4.3	Block diagrams of o/c relays, block diagram and flow chart of microprocessor-based o/c relay	1
4.4	Fundamentals of numerical relay, distance relay - impedance relay	1
4.5	Differential relay - Buchholz relay, directional relay	1
4.6	Circuit breakers - introduction, fault clearing time of a circuit breaker, arc voltage, arc interruption, restriking voltage, recovery voltage	1
4.7	Resistance switching, current chopping, interruption of capacitive current	1
4.8	Classification - SF6 circuit breakers	1
4.9	Vacuum circuit breakers	1
	Module 5: Power Distribution Systems	8
5.1	Distribution system classifications, AC distribution systems - connection schemes - radial and ring main systems, types of AC distributors	2
5.2	Power factor referred to sending end voltage (single phase only)	1
5.3	Power factor referred to respective load voltage (single phase only)	1
5.4	Method of power factor improvement using capacitors	1
5.5	Tariff - different types, numerical problems	2
5.6	Introduction to energy markets - regulated and deregulated systems	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. What are the methods employed for improving the efficiency of thermal power plant?
2. How does diversity factor decide the capacity of a power station?
3. What are the limiting factors in tapping the wind and solar potential?

Course Outcome 2 (CO 2)

1. Explain the principle and causes of skin effect and Ferranti effect using appropriate figures.
2. What is transposition of lines? Comment on its necessity in the system.
3. Problems in transmission line modelling and analysis.

Course Outcome 3 (CO 3)

1. What are the critical voltages in the formation of Corona? What is the effect of Corona?
2. With a neat cross sectional view show the constructional features of an EHT Cable.
3. Problems due to sag/ corona/insulators.

Course Outcome 4 (CO 4)

1. What are the essential qualities required by any insulating medium used for arc quenching? What are the usual insulating media used?
2. What is current chopping? What is its effect on the system?
3. Problems in arc interruption.

Course Outcome 5 (CO 5)

1. Derive the equations for voltage drop and current loss in a two wire ring main distributor supplied by (i) DC and (ii) AC Voltages.
2. How does power factor affect an HT consumer's electricity bill?
3. Illustrate regulated and deregulated systems of energy markets.

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: : B24EE3T02

Course Name: : POWER SYSTEM I

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What factors are to be taken into account while selecting the site for a nuclear power station?
2. Define diversity factor and explain its significance.
3. Explain skin effect and Ferranti effect.
4. What is transposition of lines? What are its advantages?
5. Specify the requirements of insulators.
6. Brief about the necessity of FACTS devices.
7. Define the terms i) RRRV ii) Making capacity iii) PSM.
8. List the role of circuit breakers and relays in power system protection.
9. What is the significance of energy market?
10. Illustrate the following: i) Two part tariff ii) Power factor tariff.

PART B

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

11. With a neat schematic diagram explain the working of steam power plant. (14 marks)

OR

12. A generating station has the following daily load cycle :

Time (Hours)	0-6	6-10	10-12	12-16	16-20	20-24
Load (MW)	40	50	60	50	70	40

Draw the load curve and calculate (i) Units generated per day (ii) Average load and (iii) load factor. (14 marks)

13. (a) The three conductors of a 3-phase line are arranged at the corners of a triangle of sides 2 m, 2.5 m and 4.5 m. Calculate the inductance per km of the line when the conductors are regularly transposed. The diameter of each conductor is 1.24 cm. (8 marks)
- (b) A single-phase transmission line has two parallel conductors 3 m apart, radius of each conductor being 1 cm. Calculate the capacitance of the line per km (6 marks)

OR

14. Derive the expression for sending end voltage and sending end current in terms of receiving end voltage and receiving end current for medium transmission lines using nominal methods. Draw its phasor diagram (14 marks)
15. (a) A transmission line conductor at a river crossing is supported from two towers at a height of 45 m and 75 m above the water level. The span length is 300 m. Weight of the conductor is 0.85 kg/m. Determine the clearance between the conductor and water at a point midway between towers if the tension in the conductor is 2050 kg. (7 marks)
- (b) A 3-phase, 220 kV, 50 Hz transmission line consists of 1.5 cm radius conductor spaced 2 metres apart in equilateral triangular formation. If the temperature is 40°C and atmospheric pressure is 76 cm, calculate the corona loss per km of the line. Take $m_o = 0.85$. (7 marks)

OR

16. (a) In a 33 kV overhead line, there are three units in the string of insulators. If the capacitance between each insulator pin and earth is 11 % of self-capacitance of each insulator, determine (i) the distribution of voltage over 3 insulators and (ii) string efficiency. (7 marks)

- (b) With the aid of single line diagrams, differentiate between mono polar and bipolar types of HVDC links. Comment on their use in the system.

(7 marks)

17. Explain the operation of a microprocessor based over-current relay with the aid of a block diagram and flow chart. Specify its significance in power system protection.

(14 marks)

OR

18. Explain the construction and working principle of vacuum circuit breaker with the help of a neat diagram. Also mention its advantages and disadvantages.

(14 marks)

19. A single phase AC distributor AB 300 metres long is fed from end A and is loaded as under: (i) 100 A at 0.707 p.f. lagging 200 m from point A (ii) 200 A at 0.8 p.f. lagging 300 m from point A. The load resistance and reactance of the distributor is 0.2Ω and 0.1Ω per kilometre. Calculate the total voltage drop in the distributor. The load power factors refer to the voltage at the far end.

(14 marks)

OR

20. A 3-phase, 50 Hz, 400 V motor develops 100 HP (74.6 kW), the power factor being 0.75 lagging and efficiency of 93 %. A bank of capacitors is connected in delta across the supply terminals and power factor raised to 0.95 lagging. Each of the capacitance units is built of 4 similar 100 V capacitors. Determine the capacitance of each capacitor.

(14 marks)

B24EE3T03	ELECTRICAL MACHINES II	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	2	0	5	4	2024

Preamble

This course covers to the fundamental principles, constructional features, and operating behavior of synchronous and induction machines. It emphasizes performance analysis, phasor diagrams, equivalent circuits, synchronization procedures and practical control techniques. Learners will develop the skills to evaluate machine operation and apply concepts in industrial applications.

Prerequisites

Electrical Machines I

Course Outcomes

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

CO 1	Explain the construction and operating principles of synchronous generators. (Cognitive Knowledge Level: Understand)
CO 2	Evaluate voltage regulation and efficiency of alternators using standard methods and to demonstrate understanding of synchronization techniques. (Cognitive Knowledge Level: Apply)
CO 3	Analyze performance characteristics of induction motor using phasor diagrams, torque-slip curves, and equivalent circuit models; and understand the detailed analysis of synchronous motor. (Cognitive Knowledge Level: Apply)
CO 4	Improve the performance of induction motor and apply speed control and starting methods for induction motors.(Cognitive Knowledge Level: Apply)
CO 5	Describe the performance of induction generator; and explain the types of single phase induction motors and their working principle. (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	2	1			2					1
CO 2	3	2	2	1		2	2	2			1
CO 3	3	2	2	1		2					1
CO 4	3	2	2	1		2					1
CO 5	3	2	1	1		2	1	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	30	30
Apply	30	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/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 (8 hours)

Three-phase Alternators

Principle of operation, constructional features, classification- cylindrical and salient pole alternator, types of armature windings, EMF equation, elimination of harmonics from EMF waveforms. Alternator on load- circuit model, determination of synchronous impedance, phasor diagram, armature reaction - effects, losses, power flow equation, efficiency. Numerical problems.

MODULE 2 (10 hours)

Voltage Regulation of Alternators

Wound rotor type - EMF method, MMF method, Potier method, direct loading. Salient-pole type - Blondel's two reaction theory, phasor diagram, slip test for determination of X_d and X_q . Numerical problems.

Synchronous Generator

Parallel operation, synchronization of alternators - conditions, methods of synchronization, synchronizing power, synchronizing torque, effect of change in excitation and mechanical power input, output power equation - power angle characteristics.

MODULE 3 (11 hours)

Synchronous Motors

Theory of operation, phasor diagram, variation of current and power factor with excitation, mathematical expression for power developed, hunting - suppression, methods of starting, synchronous condenser. Numerical problems.

Three-Phase Induction Motors

Construction, types, principle of operation- production of rotating magnetic field, rotor emf, rotor frequency, rotor current, power factor at standstill and during operation. Losses, efficiency, torque equation- maximum torque, starting torque, torque-slip characteristics, phasor diagram, equivalent circuit. Numerical problems.

MODULE 4 (9 hours)

Performance Analysis and Speed Control of Induction Motors

No load and blocked rotor tests - predetermination of performance using circle diagram. Methods of starting - DOL starter, autotransformer starter, star-delta starter, rotor resistance starter. Speed control methods - stator voltage control, V/f control, rotor resistance control. Braking of Induction motors - plugging, dynamic braking, regenerative braking.

MODULE 5 (7 hours)

Induction Generator

Principle of operation, line excited and self-excited, torque-slip characteristics- braking, motoring and regeneration.

Single-phase Induction Motors

Principle of operation - double revolving field theory, equivalent circuit, torque-slip characteristics, types - split-phase, capacitor-start induction-run, permanent capacitor type, shaded pole, applications.

Text Books

1. Bimbhra P. S., *Electric Machines*, Khanna Publishers, 5th ed., 2021.
2. Kothari D. P., Nagrath I. J., *Electric Machines*, Tata McGraw Hill, 5th ed., 2017.
3. Say M. G., *The Performance and Design of AC Machines*, CBS Publishers, New Delhi, 3rd ed., 2012.
4. Alexander S. Langsdorf, *Theory of Alternating Current Machinery*, Tata Mc Graw Hill, 2nd ed. revised, 2011.

Reference Books

1. Deshpande M. V., *Electrical Machines*, Prentice Hall India, New Delhi, 3rd ed., 2011
2. Gupta B. R., Vandana Singhal, *Fundamentals of Electric Machines*, New Age International, 3rd ed., 2010.
3. Ashfaq Husain, Haroon Ashfaq, *Electric Machines*, Dhanpat Rai and Co., 3rd ed., 2002
4. Gupta J. B., *Theory and Performance of Electrical Machines*, S K Kataria and Sons, 15th ed., 2022.
5. B. L. Theraja, A. K. Theraja, *A text book of Electrical Technology*, vol II, S Chand, 24th ed., 2024.

6. K. Murugesh Kumar, *Induction and Synchronous Machines*, Vikas, 11th ed., 2001.
7. U. A. Bakshi, M. V. Bakshi, M. G. Unde, *Electric Machines II*, Technical publications, 1st ed., 2021.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Three-phase Alternators	8
1.1	Principle of operation, constructional features	1
1.2	Classification -cylindrical and salient pole alternator, types of armature windings	1
1.3	EMF equation, numerical problems	1
1.4	Elimination of harmonics from EMF waveforms	1
1.5	Alternator on load, circuit model, determination of synchronous impedance, phasor diagram, armature reaction-effects	2
1.6	Losses, power flow equation, efficiency,numerical problems	2
	Module 2: Voltage Regulation of Alternators	10
2.1	EMF method, numerical problems	1
2.2	MMF method, numerical problems	1
2.3	Potier method, direct loading, numerical problems	2
2.4	Blondel's two reaction theory, phasor diagram	1
2.5	Slip test for determination of X_d and X_q , numerical problems	2
	Synchronous Generator	
2.6	Parallel operation, synchronization of alternators- conditions, methods of synchronization	1
2.7	Synchronizing power, synchronizing torque	1
2.8	Effect of change in excitation and mechanical power input, output power equation - power angle characteristics	1
	Module 3: Synchronous Motors	11
3.1	Theory of operation of synchronous motor, phasor diagram, variation of current and power factor with excitation	1
3.2	Mathematical expression for power developed,numerical problem	1
3.3	Hunting - suppression, methods of starting, synchronous condenser	1
	Three Phase Induction Motors	
3.4	Construction, types, principle of operation of three-phase induction motors	1

3.5	Production of rotating magnetic field	1
3.6	Rotor emf, rotor frequency, rotor current, power factor at standstill and during operation, numerical problems	2
3.7	Losses, efficiency, numerical problems	1
3.8	Torque equation- maximum torque, starting torque, torque-slip characteristics, phasor diagram	2
3.9	Equivalent circuit, numerical problems	1
	Module 4: Performance Analysis and Speed Control of Induction Motors	9
4.1	No load and blocked rotor tests	1
4.2	Predetermination of performance using circle diagram	3
4.3	Methods of starting - DOL starter, autotransformer starter	1
4.4	Star-delta starter, rotor resistance starter	1
4.5	Speed control methods- stator voltage control, V/f control, rotor resistance control	2
4.6	Braking of Induction motors – plugging, dynamic braking, regenerative braking	1
	Module 5: Induction Generator	7
5.1	Principle of operation, line excited and self-excited	1
5.2	Torque-slip characteristics - braking, motoring and regeneration	2
	Single Phase Induction Motors	
5.3	Principle of operation - double revolving field theory	1
5.4	Equivalent circuit, torque-slip characteristics	1
5.5	Types - split-phase, capacitor-start induction-run	1
5.6	Permanent capacitor type, shaded pole, (concepts only) applications	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the principle of operation of alternators.
2. Derive emf equation of an alternator.
3. Define coil pitch factor and distribution factor of an alternator.
4. Draw the phasor diagram of an alternator operating under lagging/leading/unity power factor and hence derive an expression for the no load induced emf/phase.

Course Outcome 2 (CO 2)

1. Define voltage regulation of the alternator.
2. Illustrate slip test to determine X_d and X_q of salient pole alternator.
3. The regulation obtained by EMF method is always greater than actual value. Justify
4. Enumerate the conditions synchronising two alternators.

Course Outcome 3 (CO 3)

1. Develop the equivalent circuit and phasor diagram of synchronous motor.
2. Explain the power flow diagram of synchronous motor.
3. Explain the principle of operation of a three phase induction motor.
4. List the constructional differences between slip ring and squirrel cage induction motors.

Course Outcome 4 (CO 4)

1. Briefly explain the phenomenon of cogging and crawling in squirrel cage induction motor.
2. Discuss any two methods of speed control of 3 phase squirrel cage induction motors.
3. Explain the working of DOL/Star-Delta starter for three phase induction motors.
4. List the different methods for braking of induction motor.

Course Outcome 5 (CO 5)

1. Differentiate between induction generator and synchronous generator.
2. Enumerate application of induction generator.
3. Explain double field revolving theory.
4. Develop the equivalent circuit of single phase induction motor.

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: : B24EE3T03

Course Name: : ELECTRICAL MACHINES II

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. In a 4 pole three phase alternator, armature has 36 slots .It is using an armature winding which is short pitched by one slot. Calculate winding factor.
2. Sketch the phasor diagram of a cylindrical pole type alternator with lagging and leading power factor load.
3. X_d is greater than X_q in salient pole machine. Justify.
4. Identify the voltage regulation method which is known as the optimistic method and explain why it is known so.
5. Draw phasor diagram of under excited synchronous motor.
6. Sketch the torque slip characteristics of three phase induction motor and show the variation of rotor resistance in the characteristics.
7. 'Power factor of three phase induction motor is low at starting but it improves as the machine is loaded'. Justify the statement.
8. Explain the phenomenon of cogging and crawling in squirrel cage induction motor.
9. Sketch the torque-slip curve of single phase induction motor.
10. Illustrate how starting torque is developed in split phase induction motor.

PART B

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

11. (a) Derive the emf equation of an alternator. (4 marks)
- (b) A 50 Hz, 600 rpm, salient pole alternator has a sinusoidal flux density having a maximum value of 1 Wb/m^2 . The alternator has 180 slots wound with 2-layer, 3- turn coils. The coil span is 15 slots and phase spread is 60° . The armature diameter is 1.25 m and core length 0.45 m. find (i) flux/pole (ii) pitch factor (iii) distribution factor (iv) peak value of emf per conductor (v) peak value of emf per coil (vi) rms phase voltage if the machine is star-connected. (10 marks)

OR

12. (a) List the advantages of stationary armature type alternators over rotating armature types. (6 marks)
- (b) An 8-pole, 3-phase, 60° spread, double layer winding has 72 coils in 72 slots. The coils are short pitched by two slots. Calculate the winding factor for the fundamental and third harmonic. (8 marks)
13. (a) A 3-phase, star-connected, 1000 kVA, 11000 V alternator has rated current of 52.5 A. The ac resistance of the winding per phase is 0.45Ω .
The test results are given below:
OC test: Field current = 12.5A, Voltage between lines = 411V
SC test: Field current = 12.5A, Line current = 52.5A
Determine the full-load voltage regulation of the alternator at (a) 0.8 pf lagging and (b) 0.8 pf leading. (10 marks)
- (b) The regulation obtained by EMF method is always greater than actual value. Justify. (4 marks)

OR

14. (a) Explain method of synchronization of alternators by using dark lamp method. (6 marks)
- (b) A 550V, 55 kVA, 1-phase alternator has an effective resistance of 0.2 ohm. A field current of 10 A produces an armature current of 200 A on short circuit and an electromotive force of 450 V on open circuit. Calculate (a) the synchronous impedance and reactance, and (b) the full load regulation with power factor 0.8 lagging. (8 marks)

15. (a) Explain the effects of varying excitation on armature current and power factor in a synchronous motor. Draw V curve and Inverted V curve. (8 marks)
- (b) A 3-phase, 440V, 50Hz star connected synchronous motor takes 7.46kW from the 3-phase supply mains. The resistance per phase of the armature winding is 0.5. The motor operates at a pf of 0.75 lag. Iron and mechanical losses amount to 500W. The excitation loss is 650W. Assume the source for excitation to be a separate one. Calculate (i) armature current (ii) power supplied to motor (iii) efficiency. (6 marks)

OR

16. (a) Synchronous motor is not self starting. Justify the statement. (6 marks)
- (b) A 440 V, 50 Hz, 6-pole, 3 phase induction motor draws an input power of 76 kW from the mains. The rotor emf makes 120 complete cycles per minute. Its stator losses are 1 kW and rotor current per phase is 62 A. Calculate (a) speed (b) rotor copper losses (c) rotor resistance per phase (d) torque developed. (8 marks)
17. A 30 HP, 500 V, 50 Hz, 4 pole, 3 phase mesh connected induction motor has the following data:
(i) No load test: 500 V, 8.3 A, 1500 W
(ii) SC test: 100 V, 32 A, 1600 W
(iii) Rotor copper loss at standstill is equal to half of the total copper loss
Sketch the circle diagram and estimate the full load current and power factor. (14 marks)

OR

18. (a) Explain various methods of starting of a 3-phase induction motor. (8 marks)
- (b) Discuss any two methods of speed control of 3-phase squirrel cage induction motors. (6 marks)
19. (a) Explain classification of induction generator based on modes of operation with neat sketches. (10 marks)
- (b) Sketch and torque - slip curve of single phase induction motor. (4 marks)

OR

20. (a) Explain working of capacitor start induction motor and shaded pole type single phase induction motor with neat sketches. (8 marks)
- (b) Mention few applications of single phase induction motor. (6 marks)

B24EE3T04	INSTRUMENTATION SYSTEMS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

The course is designed to equip students with a comprehensive understanding of the principles, components, and applications that support intelligent measurement systems. Students will gain foundational understanding about signal conditioning, processing circuits and data acquisition systems. By the end of this course, students will possess both theoretical knowledge and practical skills essential for designing, analyzing, and implementing instrumentation and control systems in contemporary engineering environments.

Prerequisites

Electrical Measurements

Course Outcomes

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

CO 1	Understand and comprehend the concepts of measurement systems, and classification of transducers. (Cognitive Knowledge Level: Understand)
CO 2	Understand the principle and construction of various sensors and transducers suitable for industrial applications. (Cognitive Knowledge Level: Understand)
CO 3	Interpret the design aspects of signal conditioning circuits and to devise an appropriate signal conditioning circuit for measurement systems. (Cognitive Knowledge Level: Apply)
CO 4	Analyze the performance of data acquisition systems and to develop the logic for the process control applications. (Cognitive Knowledge Level: Apply)
CO 5	Familiarize with PLC programming and implementation of ladder logic for automation and describe the fundamental concepts of SCADA systems. (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					1
CO 2	2		1		1	1					2
CO 3	2	1	1	1	1	1					2
CO 4	2	1	2	1	3	1					2
CO 5	2	1	1	1	1	1					2

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	40	20	20
Understand	60	30	30
Apply		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/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)

Introduction to Instrumentation Systems

Classification of transducers - primary and secondary transducers, characteristics and choice of transducers - static and dynamic characteristics, zeroth, first and second order instruments and time responses, errors in measurement, passive transducers - resistive, inductive and capacitive transducers, active transducers - piezoelectric, Hall effect, magnetostrictive, digital transducer, feedback transducer systems.

MODULE 2 (10 hours)

Measurement of Non-electrical Quantities

Temperature measurement - RTD, thermistor, thermocouple, pressure measurement - diaphragm, bellow, capsule, bourdon tube, flow measurement - orifice meter, rotameter, electromagnetic flow meter, ultrasonic flow meter, liquid level measurement - capacitive level sensor, force measurement - strain gauge, cantilever load cell, torque measurement - magnetostrictive transducers, displacement measurement - LVDT, RVDT.

Smart Sensors

Micro sensors, IR radiation sensors, ultrasonic sensors, fibre optic sensors, Micro Electromechanical System (MEMS) - advantages, applications, micro sensors, micro actuators, accelerometers.

MODULE 3 (6 hours)

Signal Conditioning and Signal Processing Circuits

DC signal conditioning system, AC signal conditioning system, signal conditioners - differential amplifiers, instrumentation amplifiers, isolation amplifiers, charge amplifiers, voltage-current converters, voltage-frequency converters, cable transmission of current signals.

MODULE 4 (10 hours)

Data Acquisition System (DAS)

Block diagram, objectives, signal conditioning of inputs - ratio metric conversion, logarithm conversion. Single channel DAS - A/D converters, pre-amplification and filtering. Multichannel DAS - multichannel analog multiplexed system, multiplexing the outputs of sample/hold, multiplexing after A/D conversion, multiplexing low-level data. Data loggers - basic operation.

Process Control

Introduction to process control, process control block diagram - identification of elements, control system evaluation. Discrete state process control - characteristics, discrete state variables, process specifications, event sequence description.

MODULE 5 (10 hours)

Programmable Logic Controllers (PLC)

Organisation, hardware details - I/O, power supply, CPU, standards programming aspects, concept of latching, ladder programming - realisation of AND, OR, NAND, NOR and XOR logic, introduction to timer/counters - numerical exercises based on timers and counters.

SCADA Systems

Common system components - RTU, HMI, IEDs, communication systems, supervisory stations. SCADA in power systems - application functions - generation, transmission, distribution, advantages, types of data and signals in power systems, data acquisition systems, classification of SCADA systems. Protocols - IEC 60870-5-101, DNP3.

Text Books

1. A. K Sawhney, *A course in Electrical and Electronic Measurements and Instrumentation*, Dhanpat Rai, 19th ed., 2015.
2. J.B. Gupta, *A course in Electrical and Electronic Measurements and Instrumentation*, S.K. Kataria & Sons, 14th ed., 2014.
3. H.S Kalsi, *Electronic Instrumentation*, Tata Mc Graw Hill, 3rd ed., 2017.
4. Curtis D Johnson, *Process Control Instrumentation Technology*, PHI Learning, 8th ed. 2009.
5. Mini S Thomas, John D Mc Donald, *Power System SCADA and Smart Grids*, CRC Press, Taylor and Francis Group, 1st ed., 2015.

Reference Books

1. James W Dally, William F. Riley, Kenneth G McConnell, *Instrumentation for Engineering Measurements*, Wiley India(P) Ltd, 2nd ed., 2012.
2. E. O Doebelin and D.N Manik, *Doebelin's Measurement systems*, Mc Graw Hill 6th ed., 2011.
3. Alan S. Morris, Reza Langari, *Measurement and Instrumentation, Theory and Application*, Academic Press, 2nd ed., 2015.

4. Bela G. Liptak, *Instrument Engineer's Handbook – Process Control*, Chilton Company, 4th Edition, 2006.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Introduction to Instrumentation Systems	9
1.1	Classification of transducers - primary and secondary transducers	1
1.2	Characteristics and choice of transducers, static and dynamic characteristics	1
1.3	Zero order systems, first order system - response to unit step, ramp and impulse inputs and time responses	2
1.4	Second order instruments, errors in measurement	1
1.5	Passive transducers - resistive, inductive and capacitive transducers	2
1.6	Active transducers - piezoelectric, Hall effect, magnetostrictive	1
1.7	Digital transducer, feedback transducer systems	1
	Module 2: Measurement of Non-electrical Quantities	10
2.1	Temperature measurement - RTD, thermistor, thermocouple	2
2.2	Pressure measurement - diaphragm, bellow, capsule, bourdon tube	1
2.3	Flow measurement - orifice meter, rotameter, electromagnetic flow meter, ultrasonic flow meter	2
2.4	Liquid level measurement - capacitive level sensor, force measurement - strain gauge, cantilever load cell	1
2.5	Torque measurement - magnetostrictive transducers, displacement measurement - LVDT, RVDT	1
	Smart Sensors	
2.6	Micro sensors, IR radiation sensors, ultrasonic sensors, fibre optic sensors	1
2.7	Micro Electromechanical System (MEMS) - advantages, applications, micro sensors, micro actuators, accelerometers	2
	Module 3: Signal Conditioning and Signal Processing Circuits	6
3.1	DC signal conditioning system, AC signal conditioning system	1
3.2	Signal conditioners - differential amplifiers, instrumentation amplifiers	2

3.3	Isolation amplifiers, charge amplifiers	1
3.4	Voltage-current converters, voltage-frequency converters	1
3.5	Cable transmission of current signals	1
	Module 4: Data Acquisition System (DAS)	10
4.1	Block diagram, objectives, signal conditioning of inputs - ratio metric conversion, logarithm conversion	2
4.2	Single channel DAS - A/D converters, pre-amplification and filtering	1
4.3	Multichannel DAS - multichannel analog multiplexed system, multiplexing the outputs of sample/hold	1
4.4	Multiplexing after A/D conversion, multiplexing low-level data	1
4.5	Data loggers - basic operation	1
	Process Control	
4.6	Introduction to process control, process control block diagram - identification of elements, control system evaluation	2
4.7	Discrete state process control - characteristics, discrete state variables	1
4.8	Process specifications, event sequence description	1
	Module 5: Programmable Logic Controllers (PLC)	10
5.1	Organisation, hardware details - I/O, power supply, CPU	1
5.2	Standards programming aspects	1
5.3	Ladder programming - realisation of AND, OR, NAND, NOR and XOR logic, concept of latching	2
5.4	Introduction to timer/counters - numerical exercises based on timers and counters	1
	SCADA Systems	
5.5	Common system components - RTU, HMI, IEDs, communication systems, supervisory stations	2
5.6	SCADA in power systems - application functions - generation, transmission, distribution, advantages	1
5.7	Types of data and signals in power systems, data acquisition systems	1
5.8	Classification of SCADA systems. Protocols - IEC 60870-5-101, DNP3	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Understand the classification and characteristics of transducers.
2. Derive the equations of time response of a first-order system.
3. Describe the different principles of working of transducers.

Course Outcome 2 (CO 2)

1. Explain the working of different types of transducers.
2. Problems associated with temperature measurements.
3. Understand the principle of MEMS.

Course Outcome 3 (CO 3)

1. Explain the working of various signal conditioners.
2. Explain the working of various converters.
3. Understand the cable transmission of current signals.

Course Outcome 4 (CO 4)

1. Explain signal conditioning and the different types of data acquisition systems.
2. Explain the basic principles of A/D multiplexing.
3. Draw a basic block diagram of a process control system and explain.

Course Outcome 5 (CO 5)

1. Draw and explain the architecture of a PLC.
2. Write a ladder logic to find the sum of Fibonacci numbers from 1 to 100 using for loop.
3. Describe how SCADA helps in real-time monitoring of transmission lines.

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: B24EE3T04

Course Name: INSTRUMENTATION SYSTEMS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What are the factors influencing the choice of a transducer for a given application?
2. Explain how capacitance varies with displacement in a capacitive transducer.
3. Define RTD. What is its principle of operation?
4. Write notes on IR radiation sensors and ultrasonic sensors.
5. Draw the block diagram of a DC signal conditioning system and explain the functions of each block.
6. Derive the expression for output voltage of a differential amplifier.
7. Explain logarithm conversion in DAS with an example.
8. How does discrete state process control differ from continuous process control?
9. Write a ladder program where a conveyor stops if both sensors S1 and S2 detect an object simultaneously.
10. What is the role of an RTU in SCADA?

PART B

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

11. (a) Derive the equations for the time response of a first order system when subjected to i) unit step input ii) unit ramp input. (6 marks)
- (b) Explain the working principle of resistive and inductive transducers. (8 marks)

OR

12. (a) Define the terms i) static error ii) absolute error and iii) relative error. (6 marks)
- (b) Describe the construction and principle of working of Hall effect transducers. (8 marks)
13. (a) Describe the methods for measurement of flow using (i) orifice plates and (ii) ultrasonic flow meter. (6 marks)
- (b) Explain the construction and principle of working of a LVDT. Explain how the magnitude and direction of displacement of core of an LVDT is detected. (8 marks)

OR

14. (a) Describe with neat sketches the following types of pressure measurement elements: (i) bourdon tubes and (ii) bellow. (8 marks)
- (b) With the help of neat diagram, describe the working of a cantilever load cell. (6 marks)
15. (a) Explain the principle of operation of an isolation amplifier and charge amplifier. (8 marks)
- (b) Explain the principle of operation of a V-I converter using an operational amplifier. (6 marks)

OR

16. (a) Derive the relationship between input voltage and output current in a basic V-I converter circuit. (7 marks)
- (b) Explain how a V-F converter can be used to transmit analog signals over long distances. (7 marks)
17. (a) Describe the architecture of a multichannel DAS. (7 marks)
- (b) Describe the main components of a data logger. What is the role of sampling rate in data logger operation? (7 marks)

OR

18. (a) Explain open-loop and closed-loop control systems with neat diagrams. (7 marks)
- (b) Describe event sequence description (ESD). Develop an event sequence for a start-stop motor control system. (7 marks)
19. (a) Realize AND, NAND, OR and XOR logic functions using ladder diagrams. (8 marks)
- (b) Explain the concept of latching and interlocking in PLCs with suitable ladder logic examples. (6 marks)

OR

20. (a) With a neat block diagram, explain the overall SCADA system architecture and its common components. (8 marks)
- (b) Describe the features of DNP3 protocol in SCADA systems. (6 marks)

B24HU3T05	ENTREPRENEURSHIP DEVELOPMENT AND MANAGEMENT STRATEGIES	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces students to the core principles of management and the practical skills needed to design, launch, and grow successful ventures. It covers decision-making, project management, entrepreneurial thinking, business model development, pitching, digital marketing, financial basics, and essential legal and intellectual property concepts. The course aims to equip learners with the strategic, analytical, and creative abilities required to navigate modern organisational and startup environments.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the fundamental principles and characteristics of management. (Cognitive Knowledge Level: Understand)
CO 2	Demonstrate ability in decision making and project management techniques. (Cognitive Knowledge Level: Apply)
CO 3	Apply modern marketing strategies and digital transformation to build sustainable businesses. (Cognitive Knowledge Level: Apply)
CO 4	Understand the basics of idea pitching, managing finances and using modern marketing tools. (Cognitive Knowledge Level: Understand)
CO 5	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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	1					1		1	1	1	2
CO 2	1	1	1	1		1		1	2	2	2
CO 3	1				2	2	1		1	2	3
CO 4	1				2	2	1		1	2	2
CO 5	1					1	1	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	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 (2 questions from each module), carrying 3 marks each. Part B contains two questions from each module, out of which one is to be answered. Each Part B question carries 14 marks and can have a maximum of two subdivisions.

SYLLABUS

MODULE 1 (6 hours)

Functions of Management

Management: definition, core functions, levels of management, evolution of management thought- scientific management (FW Taylor), administrative management (Henri Fayol), modern approaches. Planning - types of plans, organisational structures - departmentalisation, span of control, staffing - motivational theories.

MODULE 2 (8 hours)

Decision Making

Decision making: process, models, components, decision-making under certainty, risk and uncertainty. Decision trees.

Project Management

Network construction, arrow diagram, redundancy. Critical Path Method (CPM), Project Evaluation and Review Technique (PERT), scheduling computations, PERT time estimates, probability of completion of the project, concept of crashing.

MODULE 3 (7 hours)

Entrepreneurial Thinking and 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, idea canvas. Digital business models - freemium, subscription, platform-based. Business model canvas - develop, visualise the business model.

MODULE 4 (6 hours)

Startup Pitching, Marketing and 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 (9 hours)

Intellectual Property Rights (IPR) and Legal Framework

Overview of Intellectual Property Rights (IPR) - product patents, process patents. Pre-requisites 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 and regulatory requirements.

Text Books

1. H. Koontz, and H. Weihrich, *Essentials of Management: An International Perspective*, McGraw-Hill, 8th ed., 2009.
2. P. C. Tripathi and P. N. Reddy, *Principles of Management*, TMH, 4th ed., 2008.
3. P. Kotler, K. L. Keller, A. Koshy, and M. Jha, *Marketing Management: A South Asian Perspective*, Pearson, 14th ed., 2012.
4. M. Y. Khan, and P. K. Jain, *Financial Management*, Tata-McGraw Hill, 2008.
5. R. D. Hisrich, and M. P. Peters, *Entrepreneurship: Strategy, Developing, and Managing a New Enterprise*, McGraw-Hill Education, 4th ed., 1997.

Reference Books

1. Ricky W. Griffin, Jean M. Phillips and Stanley M. Gully, *Organizational Behavior: Managing People and Organizations*, Cengage Learning, 12th ed., 2019.
2. Stephen P. Robbins and Timothy A. Judge, *Organizational Behavior*, Pearson Education, 18th ed., 2019.
3. Heidi M. Neck, Christopher P. Neck and Emma L. Murray, *Entrepreneurship: The Practice and Mindset*, SAGE Publications Inc., 3rd ed., 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 and Dr S. Balasubramanian, *Intellectual Property Rights: Text and Cases*, Excel Books, 2008.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Functions of Management	6
1.1	Introduction to management, levels, management thoughts	2
1.2	Planning and types, organisational structures	2
1.3	Span of control and staffing concepts	2
	Module 2: Decision Making	8
2.1	Decision making and decision making environments	2
2.2	Components of decision making and Decision trees	2
	Project Management	
2.3	Project management and network construction	1
2.4	CPM and PERT Techniques	2
2.5	Problems on PERT and CPM	1
	Module 3: Entrepreneurial Thinking and Business Design	7
3.1	Entrepreneurial Mindset - Growth mindset, risk-taking, and decisionmaking	2
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	1
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)	2
	Module 4: Startup Pitching, Marketing and Financials	6
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
	Module 5: Intellectual Property Rights (IPR) and Legal Framework	9

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 and Legal Structures - Types of business entities: Sole Proprietorship, Partnership, LLP, Private Ltd, OPC. Startup India Registration – Benefits and Eligibility	2
5.5	Compliance and Regulatory Requirements - GST Registration, ROC Filings. Startup Taxation and Incentives. Taxes applicable to startups (Income Tax, GST, TDS, Angel Tax). Tax Benefits for Startups under Section 80-IAC and DPIIT	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. How do different levels of management (top, middle, lower) contribute to achieving business goals?
2. Explain the difference between classical and modern approaches to management thought.
3. How do Maslow's Hierarchy of Needs and Herzberg's Two-Factor theory explain employee motivation in the workplace?

Course Outcome 2 (CO 2)

1. Explain the types of decision making environments.
2. Differentiate CPM with PERT in project management.
3. Problems on finding probability of project completion.

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: 3

Reg.No.:

Name:

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

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: : B24HU3T05

***Course Name: : ENTREPRENEURSHIP DEVELOPMENT AND
MANAGEMENT STRATEGIES***

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. Briefly explain the decision making environments.
4. What are the advantages and disadvantages of PERT.
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.

11. How do Maslow's Hierarchy of Needs and Herzberg's Two-Factor theory explain employee motivation in the workplace?

(14 marks)

OR

12. Compare and contrast classical and modern approaches to management thought.

(14 marks)

13. Given below is a pay-off table. Given probabilities for various events are $P(E1)=0.3$, $P(E2)=0.4$ and $P(E3)=0.3$. What will be the optimal decision if the criteria followed is (i) maxi-max (ii) mini-max (iii) maxi-min (iv) Laplace (v) EMV (vi) EOL

Table 6: Event vs Action Values

Event	Action A1	Action A2	Action A3
E1	5	-1	-17
E2	18	28	30
E3	25	50	80

(14 marks)

OR

14. The data regarding the activities in a project are given below. It is given that the schedule date of completion of project is 38 days. Draw the network diagram, find the critical path and find the probability that project can be completed at schedule time.

Activity	to (Optimistic)	tm (Most Likely)	tp (Pessimistic)
1-2	2	5	14
1-6	2	5	8
2-3	5	11	29
2-4	1	4	7
3-5	5	11	17
4-5	2	5	14
6-7	3	9	27
5-8	2	2	8
7-8	7	13	31

(14 marks)

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 marks)
- (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 marks)

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 marks)
- (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 marks)
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 marks)
- (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 marks)

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 marks)
- (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 marks)
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 marks)
- (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 marks)

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 marks)
- (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 marks)

B24EE3L07	MICROPROCESSOR AND MICROCON- TROLLER LAB	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2		2024

Preamble

This course introduces students to the fundamentals of microcontroller programming and interfacing through hands-on experiments using platforms like 8085, 8051, Arduino, and Raspberry Pi. The course covers arithmetic operations, data manipulation, sensor interfacing, actuator control, IoT-based applications, and real-time embedded system development. By the end of the course, students will be able to design, implement, and demonstrate microprocessor and microcontroller-based solutions for real-world problems across domains such as automation, energy monitoring, and healthcare.

Prerequisite

Microprocessors and Microcontrollers

Course Outcomes

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

CO 1	Develop and execute assembly language programs for solving arithmetic and logical problems using microprocessor and also to interface circuits with the microprocessor. (Cognitive Knowledge Level: Apply)
CO 2	Design and implement 8051 microcontroller-based systems for time delay generation and serial transmission. (Cognitive Knowledge Level: Apply)
CO 3	Design and implement Arduino microcontroller-based systems with interfacing circuits for various applications. (Cognitive Knowledge Level: Apply)
CO 4	Identify real-world challenges and design microcontroller-based solutions using modern microcontroller platforms. (Cognitive Knowledge Level: Apply)
CO 5	Develop the team management skills and prepare laboratory reports that logically and scientifically communicate experimental information. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Mark Distribution

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

Continuous Internal Evaluation Pattern

Attendance	10 marks
Continuous Assessment	15 marks
Performance	10 marks
Viva-Voce	5 marks
Lab Record	5 marks
Internal Exam	15 marks
Micro project	5 marks

End Semester Examination (ESE) Pattern:

The following guidelines should be followed regarding the award of marks

1. Preliminary work: 25 marks
 - (a) Circuit diagram/Program: 15 marks
 - (b) Theory/Design and Procedure: 10 marks
2. Implementing the work/Conducting the experiment: 30 marks (usage of equipment and troubleshooting)
3. Result and Inference: 15 marks
4. Viva Voce: 30 marks

Micro Project: Students must complete a mandatory micro project in groups of up to four members. The project should involve the design and realization of an embedded system for industrial control/ day-to-day life applications. This project will be evaluated as part of the continuous internal evaluation, with a maximum of 5 marks.

Students having a certified Lab Record and Micro Project Report are only eligible to appear for the End Semester Examination.

SYLLABUS

LIST OF EXPERIMENTS

1	a) ALP programming to add or subtract two 8-bit numbers in different addressing modes using 8085. b) ALP programming to add an array of 8-bit numbers using 8085.
2	a) ALP programming to multiply two 8-bit numbers and display the answer in the data field using 8085. b) ALP programming to divide two 8-bit numbers and display the answer in the address field using 8085. c) ALP programming for block transfer of data using 8085.
3	a) ALP programming to sort an arrays of numbers in ascending and descending order using 8085. b) ALP programming to find the largest or smallest number in an array of numbers using 8085.
4	a) ALP programming to Convert a BCD number into a binary number and display the result in the data field using 8085. b) ALP programming to convert a binary number into a BCD number and display the result in the address field using 8085.
5	ALP programming for interfacing of 8255 with 8085 a) Interfacing of Switch and LED. b) Traffic signal control.
6	a) Introduction to Keil and Proteus for ALP programming in 8051. b) ALP programming for square wave generation using 8051. c) ALP programming for transmitting characters to a PC HyperTerminal using the serial port and displaying them in the serial window using 8051.

7	ALP programming for code conversion - BCD to ASCII, ASCII to BCD, ASCII to decimal, Decimal to ASCII, Hexadecimal to Decimal and Decimal to Hexadecimal using 8051.
8	a) Familiarisation with Arduino IDE. b) ALP programming for LED blinking with different ON/OFF delay timings with (i) in-built LED, (ii) externally interfaced LED.
9	a) ALP programming to interface I2C LCD display with Arduino. b) Arduino-based voltage measurement of a 12 V solar PV module/12 V battery and displaying the measured value using I2C LCD display.
10	a) PWM signal generation using Arduino for DC motor speed control. b) ALP programming to interface a relay with Arduino.
11	Arduino-based DC current measurement using Hall effect current sensor and displaying the value using I2C LCD module.
12	Program to upload and retrieve temperature and humidity data to cloud using Raspberry Pi.

Reference Books

1. Ramesh Gaonkar, *Microprocessor, Architecture, Programming and Applications*, Penram International Publishing, 6th ed., 2014.
2. Michael Margolis, *Arduino Cookbook*, O'Reilly Media, Inc., 3rd ed., 2020.
3. Derek Molloy, *Exploring Raspberry Pi: Interfacing to the Real World with Embedded Linux*, Wiley publications, 1st ed., 2016.
4. Mohamed Ali Mazidi, Janice Gillispie Mazidi, *The 8051 microcontroller and embedded systems using Assembly and C*, Pearson/Prentice hall of India, 2nd ed., 2006.

B24EE3L08	POWER ELECTRONICS LAB	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

This course aims to familiarize students with the design, operation, and analysis of various power electronic circuits. Students gain practical understanding of device characteristics, triggering methods, and performance of different converter circuits. Simulation and hardware experiments together provide comprehensive exposure to modern power control techniques used in industrial and motor drive applications.

Prerequisite

Power Electronics

Course Outcomes

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

CO 1	Understand the static characteristics of power semiconductor devices such as SCR and MOSFET through experimental analysis. (Cognitive Knowledge Level: Understand)
CO 2	Design and implement firing and triggering circuits for controlled converters and inverters using analog and digital techniques. (Cognitive Knowledge Level: Apply)
CO 3	Analyze the operation of various power electronic converters under different load conditions. (Cognitive Knowledge Level: Analyze)
CO 4	Apply simulation tools for modeling, analyzing, and evaluating the performance of power electronic systems. (Cognitive Knowledge Level: Apply)
CO 5	Develop the team management skills and prepare laboratory reports that logically and scientifically communicate experimental information. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Mark Distribution

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

Continuous Internal Evaluation Pattern

Attendance	10 marks
Continuous Assessment	15 marks
Performance	10 marks
Viva-Voce	5 marks
Lab Record	5 marks
Internal Exam	20 marks

End Semester Examination (ESE) Pattern:

The following guidelines should be followed regarding the award of marks

1. Preliminary work: 25 marks
 - (a) Circuit Diagram: 15 marks
 - (b) Theory and Procedure: 10 marks
2. Implementing the work/Conducting the experiment: 30 marks (usage of equipment and troubleshooting)
3. Result and Inference: 15 marks
4. Viva Voce: 30 marks

Students having a certified Lab Record are only eligible to appear for the End Semester Examination.

SYLLABUS

LIST OF EXPERIMENTS

1	a) Plot the static characteristics of SCR, measure the latching current and holding current. b) Plot the static characteristics of a power MOSFET.
2	Design and set up a half-wave-controlled rectifier using SCR with R and RC firing circuits. Determine the minimum and maximum firing angles of this circuit.
3	a) Design and set up a half-wave-controlled rectifier using SCR with UJT firing circuits. Determine the minimum and maximum firing angles of this circuit. b) Design and set up a single-phase AC voltage controller using TRIAC.
4	a) Design and set up a single-phase semi-converter with RL/RLE loads with and without a freewheeling diode. b) Design and set up a single-phase full converter with RL/RLE load with and without a freewheeling diode.
5	a) Design and set up a line-synchronised Ramp Trigger circuit for SCR. b) Design and set up the Digital Trigger circuit of SCR.
6	a) Design and set up a buck/ boost converter. b) Design of Inductor/Transformer.
7	Design and set up a single-phase half-bridge inverter.
8	Design and implement a DC chopper control circuit.
9	Generate a PWM signal for a single-phase half-bridge/full-bridge inverter using microcontroller.

10	Simulate a buck, boost and buck-boost converter using MATLAB simulation platform.
11	Simulate a 3-phase fully controlled converter with R, RL and RLE loads and observe the waveform in MATLAB Simulink.
12	Simulate a single-phase and three-phase sine PWM inverter using MATLAB.

Reference Books

1. Mohan, Undeland, and Robbins, *Power Electronics, Converters, Applications & Design*, John Wiley & Sons, 3rd ed., 2003.
2. Muhammad H. Rashid, *Power Electronics Circuits, Devices and Applications*, Prentice Hall India, 3rd ed., 2009.
3. Ned Mohan, *First course on power electronics and drives*, MNPERE, 2003.
4. L. Umanand, *Power Electronics – Essentials & Applications*, Wiley-India, 1st ed., 2009.
5. Daniel W. Hart, *Power Electronics*, Tata McGraw-Hill Education, Vol.1, 3rd ed., 2011.



PROGRAMME ELECTIVE I

B24EE3P11	BIOMEDICAL INSTRUMENTA- TION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course provides an in-depth understanding of biomedical instrumentation and the physiological principles underlying the generation and measurement of biological signals. It introduces students to various medical instruments used for diagnosis and monitoring, as well as modern developments such as imaging systems, artificial intelligence applications, telemedicine, and medical robotics. The course enables students to integrate engineering principles with medical science in the design and development of biomedical systems for healthcare applications.

Prerequisites

Electronic Circuits II, Signals and Systems

Course Outcomes

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

CO 1	Understand basic human physiological systems and bioelectric signal generation and acquisition. (Cognitive Knowledge Level: Understand)
CO 2	Explain biomedical transducers and their application in blood pressure and cardiac measurements. (Cognitive Knowledge Level: Apply)
CO 3	Apply instrumentation for the nervous, muscular, and respiratory systems. (Cognitive Knowledge Level: Apply)
CO 4	Understand the principles of modern imaging and therapeutic equipment. (Cognitive Knowledge Level: Understand)
CO 5	Understand emerging healthcare technologies and electrical safety. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	2	2	2	2		1	1				1
CO 2	3	2	2	2	2	1	1				1
CO 3	3	2	2	2	2	1	1				1
CO 4	2	2	2	2	2	1	1				1
CO 5	2	2	2	2	2	1	1				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/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 (7 hours)

Human Physiological Systems

Heart and cardiovascular system, physiology of the respiratory system, anatomy of the nervous and muscular systems, problems encountered in measuring living systems.

Bioelectric Signals and Electrodes

Bioelectric potential, resting and action potential, generation and propagation, bioelectric potentials associated with physiological systems (ECG, EEG and EMG), noise and artefacts in biological signals and their management.

Bio potential Electrodes - surface electrode, microelectrode, needle electrodes.

MODULE 2 (8 hours)

Transducers for Biomedical Applications

Measurement of physiological parameters such as pressure, temperature, and respiration rate.

Measurement of Blood Pressure

Direct and indirect measurement - Oscillometric method, ultrasonic method. Measurement of blood flow and cardiac output - plethysmography, photoelectric and impedance plethysmographs. Measurement of heart sounds - phonocardiography.

Cardiac Measurements

Electro-conduction system of the heart, electrocardiography, electrodes and leads, Einthoven triangle, ECG read out devices, ECG machine - block diagram.

MODULE 3 (8 hours)

Measurements from the Nervous System

Neuronal communication, EEG waveforms and Features, 10-20 electrode measurement, Block diagram of EEG signal acquisition system – Brain-Computer interfacing.

Muscle Response: Electromyography- Block diagram of EMG recorders – Nerve conduction velocity measurement.

Measurements of Respiratory Parameters: Spirometer-Pneumograph

MODULE 4 (7 hours)

Modern Imaging Systems

Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and ultrasound imaging.

Therapeutic Equipments

Cardiac pacemakers, defibrillators, haemodialysis machines, artificial kidneys, lithotripsy units, shortwave and microwave diathermy machines, ventilators, heart-lung machines, and infant incubators.

MODULE 5 (6 hours)

Emerging Technologies in Healthcare

Telemedicine, applications in telemonitoring, introduction to medical robotics, Artificial Intelligence (AI) techniques - applications in medical image and signal analysis for disease diagnosis.

Electrical Safety

Physiological effects of electric current, shock hazards from electrical equipment, methods of accident prevention.

Text Books

1. L. Cromwell, F. J. Weibell and L. A. Pfeiffer, *Biomedical Instrumentation Measurements*, Pearson Education, 2nd ed., 1990.
2. J. G. Webster, *Medical Instrumentation, Application and Design*, John Wiley and Sons, 5th ed., 2020.

Reference Books

1. R. S. Khandpur, *Handbook of Biomedical Instrumentation*, Tata McGraw Hill, 3rd ed., 2014.
2. J. J. Carr and J. M. Brown, *Introduction to Biomedical Equipment Technology*, Pearson Education, 4th ed., 2000.
3. Achim Schweikard, *Medical Robotics*, Springer, 2015.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Human Physiological Systems	7
1.1	Heart and cardiovascular system, physiology of the respiratory system	1
1.2	Anatomy of the nervous and muscular systems	1
1.3	Problems encountered in measuring living systems	1
	Bioelectric Signals and Electrodes	
1.4	Bioelectric potential, resting and action potential, generation and propagation	1
1.5	Bioelectric potentials associated with physiological systems (ECG, EEG and EMG)	1
1.6	Noise and artefacts in biological signals and their management	1
1.7	Bio potential Electrodes - surface electrode, microelectrode, needle electrodes	1
	Module 2: Transducers for Biomedical Applications	8
2.1	Transducers for Biomedical Applications- Measurement of physiological parameters such as pressure, temperature, and respiration rate	1
	Measurement of Blood Pressure	
2.2	Direct and indirect measurement	1
2.3	Oscillometric method, ultrasonic method	1
2.4	Measurement of blood flow and cardiac output - plethysmography	1
2.5	Photoelectric and impedance plethysmographs	1
2.6	Measurement of heart sounds - phonocardiography	1
	Cardiac Measurements	
2.7	Electro-conduction system of the heart, electrocardiography, electrodes and leads, Einthoven triangle	1
2.8	ECG read out devices, ECG machine - block diagram	1
	Module 3: Measurements from the Nervous System	8
3.1	Neuronal communication	1
3.2	EEG waveforms and Features	1
3.3	10-20 electrode measurement	1
3.4	Block diagram of EEG signal acquisition system – Brain-Computer interfacing	1
	Muscle Response	
3.5	Electromyography, Block diagram of EMG recorders	1
3.6	Nerve conduction velocity measurement	1
	Measurements of Respiratory Parameters	
3.7	Spirometer	1
3.8	Pneumograph	1
	Module 4: Modern Imaging Systems	7

4.1	Computed Tomography (CT)	1
4.2	Magnetic Resonance Imaging (MRI), ultrasound imaging	1
	Therapeutic Equipments	
4.3	Cardiac pacemakers, defibrillators	1
4.4	Haemodialysis machines, artificial kidneys, lithotripsy units	1
4.5	Shortwave and microwave diathermy machines	1
4.6	Ventilators	1
4.7	Heart-lung machines, and infant incubators	1
	Module 5: Emerging Technologies in Healthcare	6
5.1	Telemedicine, applications in telemonitoring	1
5.2	Introduction to medical robotics	1
5.3	Introduction to Artificial Intelligence (AI) techniques (Brief idea only)- Basic concept of AI, difference between AI, Machine Learning, and Deep Learning, Scope of AI in Biomedical Engineering	1
5.4	Applications of AI in medical image and signal analysis for disease diagnosis	1
	Electrical Safety	
5.5	Physiological effects of electric current	1
5.6	Shock hazards from electrical equipment, methods of accident prevention	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the anatomy of the heart and cardiac system.
2. Describe the physiology of the respiratory system.
3. Discuss the generation and propagation of action potential with neat sketches.

Course Outcome 2 (CO 2)

1. Explain the direct method of blood pressure measurement.
2. Explain the Oscillometric method of blood pressure measurement.
3. Explain the measurement of Cardiac output.

Course Outcome 3 (CO 3)

1. Explain the 10-20 system of EEG electrodes placement.
2. Draw and explain the block diagram of EMG recorder.
3. Explain the measurement of respiratory parameters using spirometer.

Course Outcome 4 (CO 4)

1. Explain the principle of MRI scanning.
2. Explain demand pacemaker with a neat block diagram.
3. Explain artificial kidney with neat sketches.

Course Outcome 5 (CO 5)

1. Draw the block diagram of a telemetry system.
2. Explain the steps involved in AI-based medical image analysis for disease detection.
3. What are the different methods of accident prevention in hospitals?

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: : B24EE3P11

Course Name: : BIOMEDICAL INSTRUMENTATION

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Discuss the functional organisation of the peripheral nervous system.
2. What are Microelectrodes?
3. What is blood pressure? How it is measured?
4. Explain Einthoven triangle.
5. With neat sketches, explain the different electrode placement schemes of ECG.
6. Explain the 10-20 system of EEG electrode placement.
7. Explain the basic principle of the ultrasonic imaging system.
8. Explain microwave diathermy.
9. What do you mean by telemedicine?
10. Differentiate between macro shock and micro shock.

PART B

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

11. (a) Discuss the problems encountered in measurement on biological systems.
(7 marks)

- (b) Explain the construction and working principle of microelectrodes. (7 marks)

OR

12. (a) Explain the equivalent circuit of the bio-potential electrode interface. (8 marks)
- (b) Write a short note on 1) resting potential 2) action potentials. (6 marks)
13. (a) With the help of a neat diagram, explain phonocardiography. (8 marks)
- (b) Explain with the help of a neat diagram, impedance plethysmograph for measurement of blood flow. (6 marks)

OR

14. Discuss the electrical conduction pathway of the heart and explain the working principle of an artificial cardiac pacemaker with necessary figures. (14 marks)
15. (a) Draw the different EEG waveforms and state their frequency. (7 marks)
- (b) Draw and explain the block diagram of the EEG machine. (7 marks)

OR

16. (a) Draw and explain the block diagram of EMG recorder. (7 marks)
- (b) Explain the measurement of respiratory parameters using a spirometer. (7 marks)
17. (a) Explain the principle of MRI scanning. (7 marks)
- (b) What are the types of CT scanning? (7 marks)

OR

18. (a) Mention different types of ventilators and write brief notes on the biomedical applications. (8 marks)
- (b) What is an infant incubator? How does it work? (6 marks)
19. (a) Write a note on medical robotics. (7 marks)
- (b) Explain how AI helps in early disease detection using medical images and signals. (7 marks)

OR

20. Explain physiological effects of electric currents and write brief notes on various susceptibility parameters. (14 marks)

B24EE3P12	RENEWABLE ENERGY SYSTEMS AND APPLICATIONS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The course provides knowledge of renewable energy systems, focusing on solar energy, wind energy, energy from ocean and other emerging technologies. The course explores the various aspects of harnessing renewable sources of energy, including their working principle, construction, classifications and applications. By the end of the course, students will be able to analyse and choose the appropriate energy source depending on the available resources.

Prerequisites

Energy Conservation and Environmental Sustainability

Course Outcomes

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

CO 1	Explain the environmental aspects of energy systems, global climate frameworks, classify energy resources and analyze solar radiation principles along with the working characteristics of solar thermal systems. (Cognitive knowledge Level: Understand)
CO 2	Analyze the characteristics and performance of solar photovoltaic systems and apply design principles for stand-alone and grid-connected PV applications. (Cognitive knowledge Level: Apply)
CO 3	Analyze the aerodynamic principles, performance characteristics and operational schemes of wind turbines and understand the basic concepts of small hydro systems. (Cognitive knowledge Level: Apply)
CO 4	Explain the operating principles, components, and classification of tidal and OTEC systems and assess their performance, site suitability and practical constraints for sustainable ocean energy generation. (Cognitive knowledge Level: Understand)
CO 5	Explain biomass energy conversion processes and biogas technologies, and describe emerging sustainable energy systems such as fuel cells, hydrogen, ethanol, and space-based power for modern renewable energy applications. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	3	1		2	2				2
CO 2	3	3	2	2	2	2					2
CO 3	3	2	2	1		2					2
CO 4	3	2	2	1		2					2
CO 5	3	2	2	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	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 (8 hours)

Introduction to Renewable Energy Systems

Environmental aspects of energy, ecology, green power - United Nations Framework Convention on Climate Change (UNFCCC), environment - economy, energy and sustainable development - Kyoto protocol, classification of energy resources - renewable energy resources - non-renewable energy resources.

Solar Thermal Systems

Introduction, solar constant, basic sun-earth angles, measurement of solar radiation, numerical problems. Pyranometer, pyrliometer, solar thermal collectors - general description and characteristics - flat plate collectors, heat transfer processes, solar concentrators - parabolic trough, parabolic dish, central tower collector, solar cooker, solar furnace, solar greenhouse, solar water heater.

MODULE 2 (8 hours)

Solar Electric Systems

Solar Photovoltaic: solar cell fundamentals, characteristics, classification, construction of module, panel and array, series and parallel combination of PV modules, effect of shadowing, maximum power point tracker (MPPT) - buck-boost converter.

Solar PV systems - stand-alone, grid-connected, design steps for a stand-alone system, efficiency of the PV module, energy balance equations for PV modules, applications, street lighting, domestic lighting, solar water pumping systems.

MODULE 3 (7 hours)

Wind Energy

Wind turbine types – HAWT, VAWT, construction, wind power curve, Betz's Law, power from a wind turbine, numerical problems. Wind turbine aerodynamics, Wind Energy Conversion System (WECS) - Fixed speed drive scheme, variable speed drive scheme, effect of wind speed and grid condition - system integration, wind energy programs in India.

Small Hydro Power

Micro, mini, small hydro projects - Basic concepts, types of turbines - classification, characteristics, selection.

MODULE 4 (7 hours)

Ocean Energy

Tidal Energy: Principle of tidal power, Tidal Power Plant (TPP) - components, classification, advantages, limitations.

Ocean Thermal Energy Conversion (OTEC): Principle, block diagram of OTEC system, methods of OTEC power generation - open cycle (Claude cycle), closed cycle (Anderson cycle) and hybrid cycle, site selection criteria, biofouling, advantages, limitations of OTEC.

MODULE 5 (6 hours)

Biomass Energy

Photosynthesis process, biomass fuels, biomass conversion technologies, urban waste to energy conversion, factors affecting biogas generation, types of biogas plants - KVIC, Janata model.

Emerging Technologies Fuel cell, hydrogen energy, ethanol energy, power from satellite stations.

Text Books

1. G. N. Tiwari, *Solar Energy-Fundamentals, Design, Modelling and Applications*, Narosa Publishers, 2nd ed., 2019.
2. D. P. Kothari, K.C.Singal and Rakesh Ranjan, *Renewable Energy Sources and Emerging Technologies*, Prentice Hall of India, 2nd ed., 2011.
3. G. D. Rai, *Non Conventional Energy Sources*, PHI Learning, 6th ed., 2022.

Reference Books

1. Khan B. H., *Non-Conventional Energy Resources*, Tata McGraw Hill, 6th ed., 2017.
2. Sawhney G. S., *Non-Conventional Energy Resources*, PHI Learning, 2nd ed., 2012.
3. David M. Buchila, Thomas E. Kissell and Thomas L. Floyd, *Renewable Energy Systems*, Pearson Education, 1st ed., 2017.
4. D. P. Kothari & S. Umashankar, *Wind Energy Systems and Applications*, Narosa, 1st ed., 2017.
5. D. Mukherjee and S. Chakrabarti, *Fundamentals of Renewable Energy Systems*, New Age International Private Limited, 1st ed., 2004.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Renewable Energy Systems	8
1.1	Environmental aspects of energy, ecology, green power, United Nations Framework Convention on Climate Change (UNFCCC)	1
1.2	Kyoto protocol, classification of energy resources - renewable energy resources - non-renewable energy resources	1
	Solar Thermal Systems	
1.3	Introduction, solar constant, basic sun-earth angles	1
1.4	Measurement of solar radiation, numerical problems. Pyranometer, pyrheliometer	1
1.5	Solar thermal collectors - general description and characteristics - flat plate collectors, heat transfer processes	1
1.6	Solar concentrators - parabolic trough, parabolic dish, central tower collector	1
1.7	Solar cooker, solar furnace, solar greenhouse	1
1.8	Solar water heater, Environment - economy, energy and sustainable development	1
	Module 2: Solar Electric Systems	8
2.1	Solar Photovoltaic: solar cell fundamentals	1
2.2	Characteristics, classification, construction of module, panel and array	1
2.3	Series and parallel combination of PV modules, effect of shadowing	1
2.4	Maximum power point tracker (MPPT) - buck-boost converter	1
2.5	Solar PV systems - stand-alone, grid-connected	1
2.6	Design steps for a stand-alone system, efficiency of the PV module	1
2.7	Energy balance equations for PV modules, applications, street lighting	1
2.8	Domestic lighting, solar water pumping systems	1
	Module 3: Wind Energy	7
3.1	Wind turbine types – HAWT, VAWT, construction	1
3.2	Wind power curve, Betz's Law, power from a wind turbine, numerical problems	1
3.3	Wind turbine aerodynamics	1
3.4	Wind Energy Conversion System (WECS) - Fixed speed drive scheme, variable speed drive scheme	1

3.5	Effect of wind speed and grid condition - system integration, wind energy programs in India	1
	Small hydro power	
3.6	Micro, mini, small hydro projects - Basic concepts	1
3.7	Types of turbines - classification, characteristics, selection	1
	Module 4: Ocean Energy	7
4.1	Principle of tidal power, Tidal Power Plant (TPP)	1
4.2	Components, classification, advantages, limitations	1
4.3	Ocean Thermal Energy Conversion (OTEC): Principle, block diagram of OTEC system	1
4.4	Methods of OTEC power generation	1
4.5	Open cycle (Claude cycle), closed cycle (Anderson cycle)	1
4.6	Hybrid cycle, site selection criteria	1
4.7	Biofouling, advantages, limitations of OTEC	1
	Module 5: Biomass Energy	6
5.1	Biomass Energy, Photosynthesis process	1
5.2	Biomass fuels, biomass conversion technologies	1
5.3	Urban waste to energy conversion, factors affecting biogas generation	1
5.4	Types of biogas plants - KVIC, Janata model	1
	Emerging Technologies	
5.5	Fuel cell, hydrogen energy	1
5.6	Ethanol energy, power from satellite stations	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain UNFCCC.
2. Problems on solar radiation.
3. Illustrate central tower collector.

Course Outcome 2 (CO 2)

1. Explain MPPT using buck boost converter.
2. Limitations of stand-alone PV system.
3. Design of stand-alone PV system.

Course Outcome 3 (CO 3)

1. Explain wind turbine aerodynamics.
2. Explain micro hydro projects.
3. Problems on power from a wind turbine.

Course Outcome 4 (CO 4)

1. Illustrate components of tidal power plant.
2. Explain Claude cycle and Anderson cycle.
3. Limitations of OTEC.

Course Outcome 5 (CO 5)

1. Outline the principle of urban waste to energy conversion.
2. Draw the diagram of KVIC biogas plant.
3. Illustrate how to harness power from satellite stations.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: : B24EE3P12

Course Name: : RENEWABLE ENERGY SYSTEMS AND APPLICATIONS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Discuss the relevance of the Kyoto Protocol.
2. Explain the terms solar constant, zenith angle and azimuth angle.
3. Draw and explain the V- I characteristics of a solar cell.
4. Explain the effect of shadowing in a solar PV system.
5. Differentiate between HAWT and VAWT.
6. Illustrate the power output versus wind speed characteristics of a wind turbine.
7. Enumerate the methods to prevent biofouling.
8. List the advantages and limitations of tidal power plants.
9. Describe the relevance of hydrogen energy in the current energy scenario.
10. Enumerate the factors affecting biogas generation.

PART B

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

11. (a) Illustrate the working of a pyrheliometer. (8 marks)
(b) Discuss the relation between energy and sustainable development. (6 marks)

OR

12. (a) Illustrate parabolic trough and central tower collector. (8 marks)
(b) Discuss the importance of Green power. (6 marks)
13. (a) Discuss the series and parallel combination of PV modules. (5 marks)
(b) Explain how Maximum Power Point Tracking can be done using a buck boost converter. (9 marks)

OR

14. (a) With the help of a diagram, explain solar water pumping systems. (6 marks)
(b) Illustrate how a standalone solar PV system can be designed. (8 marks)
15. Explain the parts, their function and working of a wind power plant with a neat diagram.

OR

16. (a) Derive the expression for power in the wind turbine. (8 marks)
(b) Compare Micro, mini and small hydro projects. (6 marks)
17. (a) Explain the classification of tidal power plants. (6 marks)
(b) State the principle of Ocean Thermal Energy Conversion (OTEC). Explain the working of closed cycle OTEC system. (8 marks)

OR

18. (a) Discuss the factors to be considered for site selection of OTEC plants. (6 marks)
(b) Illustrate the components of tidal power plant. (8 marks)
19. (a) Explain the working of fuel cell. (6 marks)
(b) Explain how power can be extracted using satellite stations. (8 marks)

OR

20. (a) Discuss the methods of urban waste to energy conversion. (6 marks)
(b) Illustrate KVIC and Janata model biogas plants. (8 marks)

B24EE3P13	HIGH VOLTAGE ENGINEERING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces basic terms and techniques applicable to high voltage ac and dc networks. It gives an insight about generation of different type of high voltage waveforms, their measurement, different testing methods for HV systems and breakdown phenomenon in insulating mediums. It also provides a basic idea of FACTS devices, HVDC transmission and few applications of high voltage engineering.

Prerequisites

Electrical Measurements, Power Electronics

Course Outcomes

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

CO 1	Explain the principles and methods used to generate high DC, AC, and impulse voltages and currents. (Cognitive Knowledge Level: Understand)
CO 2	Apply methods to measure high voltage, current and dielectric characteristics in high voltage systems. (Cognitive Knowledge Level: Apply)
CO 3	Understand dielectric behavior and breakdown mechanisms in solid, liquid and gaseous media and explain insulation systems used for high-voltage applications. (Cognitive Knowledge Level: Understand)
CO 4	Identify the main components and functions of HVDC transmission and FACTS controllers in power systems. (Cognitive Knowledge Level: Understand)
CO 5	Explain high-voltage testing of power equipments and outline key applications of high-voltage engineering. (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
CO 2	3	3	2								2
CO 3	3	3									2
CO 4	3	3									2
CO 5	3	3				2					2

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	30	40	30
Understand	50	60	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/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 (7 hours)

Generation of High Voltage DC and AC

Generation of high DC voltage - rectifier circuit, voltage multiplier circuit - cascaded voltage multiplier circuit, Cockroft-Walton voltage multiplier circuit, Vande Graff generator, generation of high AC voltage - cascaded transformers, series resonant circuit.

Generation of Impulse Voltages and Currents

Impulse voltage - standard impulse wave shapes, construction of impulse generator, Marx generator, multistage impulse generator circuit, impulse current generation.

MODULE 2 (7 hours)

Measurement of High Voltages

Sphere gaps - factors affecting sphere gap measurement, peak voltage measurement using sphere gap, electrostatic voltmeter, generating voltmeter and sensors, resistance voltage dividers, capacitance voltage dividers, current measurement- Rogowski coils.

Dielectric Measurements

Measurement of dielectric constant and loss factor, partial discharge measurements - basic partial discharge (PD) circuit, PD currents, PD quantities, partial discharge measurements on high voltage gas insulated substation, corona and RIV measurements

MODULE 3 (8 hours)

Introduction to Solid, Liquid and Gaseous Dielectrics

Breakdown in gas and gas mixtures, breakdown in uniform and non-uniform fields, Paschen's law, Townsend's criterion, streamer mechanism, corona discharge, insulation systems, breakdown in electronegative gases, breakdown in liquid dielectrics, suspended particle mechanism, breakdown in solid dielectrics - intrinsic, streamer and thermal breakdown.

Insulation systems for AC voltages - cables, bushings and transformers, insulation systems for DC voltages - capacitors, HVDC bushings and cables, insulation systems for impulse voltages - impulse capacitor.

MODULE 4 (7 hours)

HVDC Transmission

General principles - VSC, HVDC - main components of HVDC links - thyristor valves, converter transformer, control equipment, AC filters and reactive power control, smoothing reactor and DC filter, switchgear, surge arresters, valve cooling, auxiliary supplies.

FACTS

Converter building - power electronic support for AC systems, Static VAR Compensators (SVCs), STATCOM, series compensators, Unified Power Flow Controller (UPFC).

MODULE 5 (7 hours)

Testing of HV Systems and Applications

High voltage testing of insulators, bushings, isolators, circuit breakers, transformers, surge diverters, cables.

Applications: Lightning protection, light and laser technology, X-ray technology, electrostatic particle precipitation, ionisation, spark plugs.

Text Books

1. C. L. Wadhwa, *High Voltage Engineering*, New Age International Publishers, 4th ed., 2020.
2. Andreas Kuchler, *High Voltage Engineering Fundamentals-Technology Applications*, Springer, 5th ed., 2018.
3. Rakosh Das Begamudre, *High Voltage Engineering, Problems and Solutions*, New Age International Publishers, New Delhi, 1st ed., 2010.

Reference Books

1. Naidu M. S. and Kamaraju V., *High voltage Engineering*, Tata McGraw Hill Publishing Company Ltd., 6th ed., 2020.
2. Farouk A. M. Rizk & Giao N. Trinh, *High Voltage Engineering*, CRC Press, 1st ed., 2014.
3. Dieter Kind, Kurt Feser, *High Voltage Test Techniques*, Reed Educational and Professional Publishing Ltd., 2001.
4. Hugh M. Ryan, *High-Voltage Engineering and Testing*, IET Power and Energy Series, 2013.

5. Kuffel, E., Zaengl, W. S. and Kuffel J., *High Voltage Engineering Fundamentals*, Elsevier India Pvt Ltd, 2005.
6. N.G. Hingorani and L.Gyugyi, *Understanding FACTS*, IEEE Press, 2000.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Generation of High Voltage DC and AC	7
1.1	Generation of high DC voltage - rectifier circuit, voltage multiplier circuit - cascaded voltage multiplier circuit	1
1.2	Cockroft-Walton voltage multiplier circuit	1
1.3	Vande Graff generator	1
1.4	Generation of high AC voltage - cascaded Transformers	1
1.5	Series resonant circuit	1
	Generation of Impulse Voltages and Currents	
1.6	Impulse voltage - standard impulse wave shapes, construction of impulse generator, Marx generator	1
1.7	Multistage impulse generator circuit, impulse current generation	1
	Module 2: Measurement of High Voltages	7
2.1	Sphere gaps - factors affecting sphere gap measurement, peak voltage measurement using sphere gap	1
2.2	Electrostatic voltmeter, generating voltmeter and sensors	1
2.3	Resistance voltage dividers, capacitance voltage dividers	1
2.4	Current measurement - Rogowski coils	1
	Dielectric Measurements	
2.5	Measurement of dielectric constant and loss factor	1
2.6	Partial discharge measurements - basic partial discharge (PD) circuit, PD currents, PD quantities	1
2.7	Partial discharge measurements on high voltage gas insulated substation, corona and RIV measurements	1
	Module 3: Introduction to Solid, Liquid and Gaseous Dielectrics	8
3.1	Breakdown in gas and gas mixtures, breakdown in uniform and non-uniform fields	1
3.2	Paschen's law, Townsend's criterion	1
3.3	Streamer mechanism, corona discharge, insulation systems	1
3.4	Breakdown in electronegative gases, breakdown in liquid dielectrics, suspended particle mechanism	1

3.5	Breakdown in solid dielectrics - intrinsic, streamer and thermal breakdown	1
3.6	Insulation systems for AC voltages - cables, bushings and transformers	1
3.7	Insulation systems for DC voltages - capacitors, HVDC bushings and cables	1
3.8	Insulation systems for impulse voltages - impulse capacitor	1
	Module 4: HVDC Transmission	7
4.1	General principles - VSC, HVDC - main components of HVDC links	1
4.2	Thyristor valves, converter transformer, control equipment	1
4.3	AC filters and reactive power control, smoothing reactor and DC filter	1
4.4	Switchgear, surge arresters, valve cooling, auxiliary supplies	1
	FACTS	
4.5	Converter building - power electronic support for AC systems, Static VAR Compensators (SVCs)	1
4.6	STATCOM, series compensators	1
4.7	Unified Power Flow Controller (UPFC)	1
	Module 5: Testing of HV Systems and Applications	7
5.1	High voltage testing of insulators, bushings	1
5.2	Isolators, circuit breakers	1
5.3	Transformers, surge diverters	1
5.4	Cables, Lightning protection	1
5.5	Light and laser technology, X-ray technology	1
5.6	Electrostatic particle precipitation, ionisation	1
5.7	Spark plugs	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Describe the working principle of a cascaded voltage multiplier circuit.
2. Define resonant frequency in a series resonant circuit.
3. Explain the principle of impulse current generation.

Course Outcome 2 (CO 2)

1. Illustrate how peak voltage measurement is done using sphere gap.
2. Give the basic principle of generating and electrostatic voltmeter.

3. Describe the measurement of corona losses.

Course Outcome 3 (CO 3)

1. State Paschen's Law.
2. Explain breakdown in electronegative gases.
3. List any four insulating materials used in transformer insulation.

Course Outcome 4 (CO 4)

1. Write a detailed note on thyristor valves used in HVDC systems.
2. Explain the function of surge arrestors used in HVDC systems.
3. Describe the structure and operation of STATCOM.

Course Outcome 5 (CO 5)

1. Describe how surge arresters are tested in high voltage systems.
2. Explain spark plug operation in internal combustion engines.
3. Outline the principle of laser generation.

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: : B24EE3P13

Course Name: : HIGH VOLTAGE ENGINEERING

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define an impulse voltage and explain the standard impulse wave shapes.
2. Discuss the working principle of series resonant circuit used for the generation of high voltage AC.
3. Define dielectric constant and loss factor and draw the basic partial discharge circuit.
4. List and explain the factors affecting the breakdown voltage of a sphere gap.
5. State Townsend's criterion for breakdown in gases.
6. Draw and explain the insulation structure of an HVDC cable.
7. Define reactive power control in HVDC systems.
8. Compare the performance of SVC and STATCOM.
9. Explain dry and wet flashover testing of insulators.
10. Discuss how high voltage is used to enhance X-ray generation.

PART B

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

11. (a) With a neat sketch explain the Cockcroft Walton voltage multiplier circuit for generation of high DC voltage. (10 marks)
- (b) List the merits and demerits of Van de Graff generator. (4 marks)

OR

12. (a) Explain the principle of generating high AC voltage using cascaded transformers. (10 marks)
- (b) Define the front and tail times of an impulse wave and specify the tolerances allowed as per the specifications. (4 marks)
13. (a) Explain how partial discharge measurements are conducted on a high-voltage gas-insulated substation. (10 marks)
- (b) Explain the operation of a resistance voltage divider circuit. (4 marks)

OR

14. (a) Explain the operation of Rogowski coil and how it is used for the measurement of high impulse currents. (10 marks)
- (b) Enumerate the reason for using sphere type electrodes in HV measurement. (4 marks)
15. (a) Explain intrinsic, thermal, and streamer breakdown in solid dielectrics. (8 marks)
- (b) Compare breakdown phenomena in uniform and non-uniform fields. (6 marks)

OR

16. (a) Give a detailed note on insulation systems for impulse voltages. (8 marks)
- (b) List the insulation components used in transformers and describe their functions. (6 marks)
17. With a neat diagram, explain the construction and operation of series compensators and UPFC. (14 marks)

OR

18. Elaborate on the main components of HVDC links.

(14 marks)

19. (a) List the various tests performed on high voltage cables.

(10 marks)

(b) Describe the short-circuit test on circuit breakers.

(4 marks)

OR

20. (a) Explain the principle of lightning protection for transmission lines.

(7 marks)

(b) Explain the working of an electrostatic precipitator (ESP) in detail.

(7 marks)

B24EE3P14	MICRO - CONTROLLERS FOR EMBEDDED SYSTEM DESIGN	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4		

Preamble

This course aims to provides a solid foundation for the 8051 and PIC microcontrollers and develop embedded systems for various applications. Additionally, the course gives an overview of controllers and peripheral devices for interfacing. After the completion of the course, students will be to design a controller based system to perform a specific set of tasks for real time applications.

Prerequisites

Microprocessors and Microcontrollers

Course Outcomes

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

CO 1	Understand the fundamentals of 8051 Microcontroller. (Cognitive Knowledge Level: Understand)
CO 2	Design and develop embedded systems using 8051 controller. (Cognitive Knowledge Level: Apply)
CO 3	Design and develop embedded systems using 8051 controller. (Cognitive Knowledge Level: Apply)
CO 4	Understand the fundamentals of PIC16 Microcontroller. (Cognitive Knowledge Level: Understand)
CO 5	Develop and implement the solutions for real time systems using any high performance Microcontroller. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	1		1		1	1		1
CO 2	3	2	3	2	2	2	1	2		1	2
CO 3	3	2	3	2	2	2	1	2		1	2
CO 4	3	2	1	1		1		1	1		1
CO 5	3	2	3	2	2	2	1	2		1	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/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 (6 hours)

8051 Microcontroller - Introduction

Applications of microcontrollers in embedded systems, 8051 Microcontroller - features and specifications, internal architecture, pin configuration and functions, memory organisation - program memory and data memory, internal RAM and ROM, external memory interfacing, stack and stack pointer.

MODULE 2 (9 hours)

8051 Programming

Instruction set - data transfer instructions, arithmetic and logical instructions, bit manipulation instructions, control transfer (branching) instructions. Assembly language programs, addressing modes - immediate, direct, register, indirect, and indexed addressing modes, arithmetic operations, logical operations, I/O Port programming. C programming for embedded system development.

Timers and Counters

Concept, timer modes, programming timers for delays and event counting. Interrupts: interrupt structure and vector table, interrupt priorities, programming external and internal interrupts, applications of interrupts in embedded systems.

MODULE 3 (6 hours)

8051 Serial Communication and Peripheral Interfacing

Basics of serial communication, UART - configuration, serial communication programming - mode selection, baud rate configuration. Peripheral interfacing - LED and switch interfacing, interfacing - 7-segment displays, analog to digital converter, digital to analog converter, LCD interfacing, keypad interfacing, interfacing with 8255 and DS12887 RTC.

MODULE 4 (9 hours)

Microchip PIC 16F877A

Features and specifications of the PIC family of devices, PIC16F877A - architecture, memory organisation, interrupt structure, instruction set, and addressing modes. Timers, counters, Capture Compare and PWM (CCP) module. Master Synchronous Serial Port (MSSP) module, A/D converter module, comparator module. Typical functions and assembly/C-language programming. Overview of PIC18F and dsPIC30F.

MODULE 5 (6 hours)

Automation and Control Applications

Motor Control: PWM generation, pulse measurement, relays and opto-isolators, stepper motor interfacing, DC motor interfacing using H-bridge, servo motor interfacing, microcontroller-based speed measuring instrument, digital thermometer, embedded system for time and temperature monitor and control.

Text Books

1. Muhammad Ali Mazidi, Janice Gillispie, Rolind D. Mckinlay, *The 8051 Microcontroller and Embedded Systems - using assembly and C*, PHI, 2nd ed., 2007.
2. Muhammad Ali Mazidi, Rolind D. Mckinlay, Danny Causey, *PIC Microcontroller and Embedded Systems – using assembly and C for PIC18*, Pearson, 1st ed., 2013.
3. Kenneth J Ayala, Dhananjay V Gadre, Anurag Chugh, *The 8051 Microcontroller and Embedded Systems - using assembly and C*, Cengage Learning India Pvt. Ltd, 4th ed.
4. Ajay V Deshmukh, *Microcontrollers Theory and Applications*, Tata McGraw-Hill Pvt. Ltd. 5th ed., 2010.

Reference Books

1. Ajit Pal *Microcontrollers Theory and Applications*, PHI, 2nd ed., 2014.
2. Ramesh Gaonakar, *Fundamentals of Microcontrollers and Applications in Embedded Systems*, Penram International Publishing Pvt. Ltd., 2007.
3. Raj Kamal& Fredrick Driscoll, *Embedded Systems Architecture, Programming and Design*, Tata McGraw-Hill, 2nd ed., 2010.
4. Data Sheet *PIC16F87XA, 28/40/44- Pin Enhanced Flash Microcontrollers*, Microchip Technology Inc., 2003.
5. Datasheet *8051 hardware Description*, Intel Corporation, 1992.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: 8051 Microcontroller - Introduction	6
1.1	Applications of microcontrollers in embedded systems, 8051 microcontroller - Features and specifications	1
1.2	Internal architecture	1
1.3	Pin configuration and functions	1
1.4	Memory organization - program memory and data memory	1
1.5	Internal RAM and ROM, external memory interfacing	1
1.6	Stack and stack pointer	1
	Module 2: 8051 Programming	9
2.1	Instruction Set - data transfer instructions, arithmetic and logical instructions	2
2.2	Bit manipulation instructions, control Transfer, (Branching) instructions. assembly language programs	1
2.3	Addressing Modes - immediate, direct, register, indirect, and indexed addressing modes, arithmetic operations, logical operations	1
2.4	I/O Port programming. C programming for embedded system development	1
2.5	Timers and Counters: concept, timer modes	1
2.6	Programming timers for delays and event counting	1
2.7	Interrupts- Interrupt structure and vector table, Interrupt priorities	1
2.8	Programming external and internal interrupts, applications of interrupts in embedded systems	1
	Module 3: 8051 Serial Communication and Peripheral Interfacing	6
3.1	Basics of serial communication, UART – configuration	1
3.2	Serial communication programming - mode selection, baud rate configuration	1
3.3	Peripheral interfacing - LED and switch interfacing, Interfacing - 7-segment displays	1
3.4	Analog to Digital Converter, Digital to Analog Converter	1
3.5	LCD interfacing, keypad interfacing	1
3.6	Interfacing with 8255 and DSI12887 RTC	1
	Module 4: Microchip PIC 16F877A	9
4.1	Features and specifications of the PIC family of devices	1
4.2	PIC16F877A - Architecture, memory organization, Interrupt structure	1
4.3	Instruction set, and addressing modes programs.	2

4.4	Timers, Counters, CCP (Capture compare and PWM) module. Block diagram, Controlling registers	2
4.5	MSSP (Master Synchronous Serial Port) module- Block diagram, Controlling registers	1
4.6	A/D Converter module, Comparator module. Block diagram, Controlling registers	1
4.7	Typical functions and Assembly/C-language programming. Overview of PIC18F and dsPIC30F	1
	Module 5: Automation and Control Applications	6
5.1	Motor Control: PWM generation, Pulse measurement, Relays and Opto-isolators	1
5.2	Stepper motor interfacing interfacing diagram, algorithm	1
5.3	DC motor interfacing using H-bridge-interfacing diagram, algorithm	1
5.4	Servo motor interfacing-interfacing diagram, algorithm	1
5.5	Microcontroller-based speed measuring instrument, Digital thermometer	1
5.6	Embedded System for Time and Temperature monitor and control	1

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. How the RAM area of 8051 uC is divided?

Course Outcome 2 (CO 2)

1. Write an embedded C program to sort the content of memory locations 10H to 20H in descending order.
2. Explain the concept of timers and counters in 8051.
3. Write an ALP to transfer 10 data bytes stored at locations starting from 21H to another location in RAM starting from 51H. Find the largest value in the data.

Course Outcome 3 (CO 3)

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 and explain the interfacing diagram of 8051 microcontroller with 8255.
3. Write a C program that continuously gets a single bit of data from P1.7 and send it to P1.0 in the main, while simultaneously Create a square wave of 200microsecond period on pin P2.5 and sending a letter A to the serial port. Use Timer0, baud rate 9600 and XTAL= 11Mhz.

Course Outcome 4 (CO 4)

1. Elaborate the architecture and explain the features of PIC 16.
2. Write a program to generate a sine wave using DAC module.
3. Explain the TIMER module of PIC16F.

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 the circuit diagram to show the interface between the 8051 uC and a DC motor.
3. Draw the circuit diagram to show the interface between the 8051 uC and a Stepper motor.

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: : B24EE3P14

Course Name: : MICROCONTROLLERS FOR EMBEDDED SYSTEM DESIGN

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the multiplexing of port pins in 8051.
2. Explain the ports in 8051 and its multiple functions.
3. List out the interrupts in 8051 and its priorities.
4. Explain the addressing modes in 8051.
5. What is the difference between AF and AIE, PF and PIE bits?
6. Draw the interfacing diagram of ADC with 8051 microcontroller.
7. Explain the interrupts of PIC16F and their priorities.
8. Explain the memory organization of PIC16F microcontroller.
9. Draw an interface of a temperature sensor and a fan to the 8051 μC .
10. Explain the algorithm to generate PWM signal.

PART B

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

11. Draw and explain the architecture of the 8051 microcontroller. (14 marks)

OR

12. How is the RAM of the 8051 microcontroller divided. Explain the memory organization of 8051 microcontroller.

(14 marks)

13. (a) WAP to get a byte of data from P0. If it is less than 100, sent to P1 otherwise send to P2.

(7 marks)

- (b) Differentiate the branching instructions SJMP, AJMP and LJMP in the 8051 microcontroller.

(7 marks)

OR

14. (a) Draw the structure and explain the interrupts of 8051 and their priorities.

(8marks)

- (b) Explain the TCON and TMOD special function registers of 8051 microcontroller.

(6 marks)

15. (a) Draw the circuit diagram to show the interface between the 8051 μC and ADC chip. Write an embedded C program to read an analog value from the potentiometer.

(7 marks)

- (b) Draw the circuit diagram to show the interface between the 8051 μC and ADC chip. Write an embedded C program to read an analog value from the potentiometer.

(7 marks)

OR

16. Illustrate the interface diagram showing the connection of the 8051 microcontroller to the DAC via port P1. Additionally, write a program to generate a ramp signal.

(14 marks)

17. (a) Explain the architecture of the PIC16F microcontroller.

(7 marks)

- (b) Explain the CCP module of PIC16F microcontroller.

(7 marks)

OR

18. (a) Draw and explain the interfacing diagram of ADC with PIC16F.

(7 marks)

- (b) Compare SPI and I2C mode of communication in PIC. Also list out the controlling registers and port pins.

(7 marks)

19. (a) Explain with diagram, how the speed the Stepper motor is controlled by PWM.

(7 marks)

- (b) Draw the circuit diagram to show the interface between the 8051 μC and a DC motor. Write an embedded C program to rotate the motor clockwise.

(7 marks)

OR

20. (a) Develop an interfacing circuit for Servo motor with 8051/PIC microcontroller.

(7 marks)

- (b) Draw an interface of a photo transistor and an LED light to the 8051 μC . Write an ALP to control the light intensity in the room.

(7 marks)

B24EE3P15	ELECTRONIC MATERIALS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course aims to familiarize the relevant concepts, principles and characteristics of electronic materials. It helps to understand and comprehend the various laws and mechanisms of semiconductor, dielectric and magnetic Materials. This course helps to analyze and compare the unique properties, characteristics and applications of materials used in electronic devices.

Prerequisites

Engineering Physics(A)

Course Outcomes

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

CO 1	Understand the fundamental physics of electronic materials and semiconductor materials. (Cognitive Knowledge Level: Understand)
CO 2	Examine the various types of dielectric materials based on the nature of electric field. (Cognitive Knowledge Level: Understand)
CO 3	Understand the characteristics of the magnetic and super conductive materials. (Cognitive Knowledge Level: Understand)
CO 4	Analyze the passive components and special purpose materials for applications associated with electrical and electronic systems. (Cognitive Knowledge Level: Apply)
CO 5	Explain and analyze the optical properties of different classes of materials and apply the principles of light-matter interaction. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	40	20	30
Understand	60	40	50
Apply		40	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 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 (7 hours)

Physics of Materials

Brief of atomic model, different types of bonding, classification of solids based on band theory, conducting materials, electrical conduction in metals based on free electron theory, electrical and thermal conductivity - Wiedemann-Franz law, thermoelectric effect, Seebeck effect, Peltier effect, factors affecting electrical conductivity of metals.

Semiconductor Materials

Classification, doping, temperature dependence, Fermi energy level, intrinsic semiconductors, extrinsic semiconductors, effect of temperature on semiconductor properties, Hall effect - solar cell, LED, semiconductor lasers.

MODULE 2 (9 hours)

Dielectric Materials

Basic Properties, classification of dielectric materials, dielectric constant, dielectric strength, dielectric loss, polarisation under static electric field - electronic, ionic, dipolar polarisation, factors affecting polarisation, electrostriction, piezo electricity.

Insulating Materials

Solid insulating materials - ceramic insulating materials, mica, porcelain, glass, polymeric insulating materials - bakelite, polyethylene, liquid insulating materials, requirement of a good insulating liquid, transformer oil, gaseous insulating materials-air, nitrogen, vacuum, ferroelectric materials.

MODULE 3 (7 hours)

Magnetic Materials

Classification of magnetic materials - diamagnetism, paramagnetism, ferromagnetism, properties of ferromagnetic materials, magnetostriction, description of magnetic materials - various types of iron, ageing, effect of impurities, losses in magnetic materials - hysteresis loss, eddy current losses, factors affecting permeability and hysteresis losses, measurement of magnetic properties.

Super Conductive Materials

Properties of superconductors - Meissner effect, types of superconductors, ideal and hard superconductors, applications, limitations.

MODULE 4 (7 hours)

Material for Passive Components

Passive and active components, introduction to resistors, manufacturing method of resistors, variable resistors, nonlinear resistors, thermistors, capacitors, important materials used for capacitors, classification of capacitors, constructional details of fixed value capacitors - mica dielectric capacitors, paper capacitors, plastic film capacitors, air capacitors.

Special Purpose Materials

Thermocouple materials, advanced thermocouple materials in electrical and electronics applications, soldering material, fuse materials, contact materials, low resistivity materials, high resistivity material, filament material, types of materials in conductors, cables and wires.

MODULE 5 (6 hours)

Optical Properties of Materials

Principles of light propagation, interaction of light with solids, types of optical materials, reflection, refraction, transmittivity, scattering, optical absorption, optical properties - metals, nonmetals, semiconductors and insulators, luminescence, optoelectronic devices, photoconductivity, photoconductive cell.

Text Books

1. K. M. Gupta and Nishu Gupta, *Advanced electrical and Electronic Materials: process and applications*, Scrivener Publications, Wiley, 2015.
2. R. K. Rajput , *Electrical Engg.Materials*, Laxmi Publications, 2nd ed., 2015.
3. Kapoor P.L , *Electrical Engineering Materials*, Khanna Publications, 2014.
4. Indulkar C. S. and Thiruvengadam S., *An introduction to electrical engineering Materials*, S. Chand & Co pvt Ltd, 6th ed., 2011.
5. P. K. Palanisamy, *Solid State Physics*, Scitech Publications, 2011.

Reference Books

1. S. O. Kasap, *Principles of Electronic Materials and Devices*, McGraw Hill Education, 4th ed., 2018.
2. L. Solymar and D. Walsh, *Electrical Properties of Materials*, Oxford university press, 9th ed., 2014.
3. T. K. Basak, *Electrical Engineering Materials* , New Academic Science Limited, 1st ed., 2012.

4. Yugang Sung, John A Rogers, William Andrew,, *Semiconductor Nanomaterials for Flexible Technologies: From Photovoltaics and Electronics to Sensors and Energy Storage/Harvesting Devices*, Elsevier, 1st ed., 2010.
5. Rolf E. Humme, *Electronic Properties of Materials*, Springer, 3rd ed., 2001.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Physics of Materials	7
1.1	Brief of atomic model, different types of bonding, classification of solids based on band theory	1
1.2	Conducting materials, electrical conduction in metals based on free electron theory	1
1.3	Electrical and thermal conductivity - Wiedemann-Franz law, thermoelectric effect, Seebeck effect, Peltier effect	1
1.4	Factors affecting electrical conductivity of metals	1
	Semiconductor Materials	
1.5	Classification, doping, temperature dependence, Fermi energy level, intrinsic semiconductors, extrinsic semiconductors	1
1.6	Effect of temperature on semiconductor properties, Hall effect	1
1.7	Solar cell, LED, semiconductor lasers	1
	Module 2: Dielectric Materials	9
2.1	Basic Properties, classification of dielectric materials	1
2.2	Dielectric constant, dielectric strength, dielectric loss	1
2.3	Polarisation under static electric field - electronic, ionic, dipolar polarisation	2
2.4	Factors affecting polarisation, electrostriction, piezo electricity	1
	Insulating Materials	
2.5	Solid insulating materials - ceramic insulating materials, mica, porcelain, glass	1
2.6	Polymeric insulating materials - bakelite, polyethylene, liquid insulating materials	1
2.7	Requirement of a good insulating liquid, transformer oil	1
2.8	Gaseous insulating materials-air, nitrogen, vacuum, ferroelectric materials	1
	Module 3: Magnetic Materials	7

3.1	Classification of magnetic materials - diamagnetism, paramagnetism, ferromagnetism	1
3.2	Properties of ferromagnetic materials, magnetostriction, description of magnetic materials - various types of iron, ageing, effect of impurities	1
3.3	Losses in magnetic materials - hysteresis loss, eddy current losses	1
3.4	Factors affecting permeability and hysteresis losses, measurement of magnetic properties	1
	Super Conductive Materials	
3.5	Properties of superconductors - Meissner effect	1
3.6	Types of superconductors, ideal and hard superconductors	1
3.7	Applications, limitations	1
	Module 4: Material for Passive Components	7
4.1	Passive and active components, introduction to resistors, manufacturing method of resistors	1
4.2	Variable resistors, nonlinear resistors, thermistors	1
4.3	Capacitors, important materials used for capacitors, classification of capacitors	1
4.4	Constructional details of fixed value capacitors - mica dielectric capacitors, paper capacitors, plastic film capacitors, air capacitors	1
	Special Purpose Materials	
4.5	Thermocouple materials, advanced thermocouple materials in electrical and electronics applications	1
4.6	Soldering material, fuse materials, contact materials, low resistivity materials, high resistivity material, filament material	1
4.7	Types of materials in conductors, cables and wires	1
	Module 5: Optical Properties of Materials	6
5.1	Principles of light propagation, interaction of light with solids	1
5.2	Types of optical materials, reflection, refraction, transmissivity	1
5.3	Scattering, optical absorption	1
5.4	Optical properties - metals, nonmetals	1
5.5	Semiconductors and insulators	1
5.6	Luminescence, optoelectronic devices, photoconductivity, photoconductive cell	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain different types of bonding.
2. Classify engineering materials based on energy gaps.
3. Derivation to determine dependence of fermi level.

Course Outcome 2 (CO 2)

1. Explain classification of dielectric materials.
2. Explain different types of polarization.
3. Derivation of dielectric constant.

Course Outcome 3 (CO 3)

1. Effects of dipole moment on magnetic materials.
2. Explain different laws related to magnetic materials.
3. Explain properties of super conductor materials.

Course Outcome 4 (CO 4)

1. List the major classifications and applications of resistors.
2. Explain the construction and working of fixed value capacitor.
3. Classify different types of conducting materials from various aspects.

Course Outcome 5 (CO 5)

1. Explain optical properties of metals, non-metals, semiconductors and insulator.
2. Explain various optical phenomena that are observed when light falls on a material.
3. Describe the phenomenon of luminescence.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: : B24EE3P15

Course Name: : ELECTRONIC MATERIALS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Classify the electrical engineering materials on the basis of their energy gaps and briefly explain each of them.
2. Enumerate different wide bandgap semiconductors. State their suitability and applications.
3. Briefly explain the classification of dielectric materials with examples.
4. What are different kinds of glass insulating materials? Write their properties and applications.
5. What are the effects of dipole moments on the magnetic behavior of materials?
6. List various properties of superconductor. Explain in brief any three properties out of them.
7. Enlist major applications of resistors and state the main materials used in them.
8. Classify different types of conducting materials from various aspects. How do the low resistivity materials differ from the high resistivity materials?
9. What do you mean by optical absorption? State the conditions of photon absorption and discuss its mechanism.
10. Enlist various optical phenomena that are observed when light falls on a material? Briefly explain each of them.

PART B

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

11. Enumerate the requirement of materials suitable for various electronic items. Make special mention of electrical, magnetic and electronic devices. (14 marks)

OR

12. Derive equations for n-type semiconductor to determine dependence of fermi level on temperature and doping concentration. (14 marks)

13. (a) What are the requirements of a good liquid insulating material? (10 marks)

- (b) Write the characteristics of transformer oil. (4 marks)

OR

14. Explain different types of polarization with neat diagrams and derive the expression for dielectric constant. (14 marks)

15. Discuss different laws being followed by various magnetic materials. What is the effect of temperature on magnetic susceptibility? (14 marks)

OR

16. What is Meissner effect? Prove that superconductors are perfect diamagnetic material. (14 marks)

17. Describe the construction and working of a fixed value paper capacitor with the help of suitable diagrams. Also write its salient features. (14 marks)

OR

18. Describe various types of conductors and cables. Explain the stranded cables, core cable, and reinforced conductor with the help of suitable diagrams. (14 marks)

19. Describe the optical properties of metals, non-metals, semiconductors and insulator. Discuss how these properties influence their applications in optoelectronic devices and photoconductive cells. (14 marks)

OR

20. Explain the phenomenon of luminescence. What are its different types? How does fluorescence differ from phosphorescence? (14 marks)

B24EE3P16	COMPUTER ORGANIZATION AND ARCHITECTURE	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course aims to cover the fundamental structure and functioning of computer systems. It covers key concepts such as processor design, instruction execution, data representation, memory hierarchy, and input/output organization. Emphasis is placed on understanding how hardware components interact to perform computations efficiently, bridging the gap between hardware and software.

Prerequisites

Digital Electronics, Microprocessors and Microcontrollers

Course Outcomes

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

CO 1	Explain the basic structure, functional units, and instruction sequencing concepts of a computer system. (Cognitive Knowledge Level: Understand)
CO 2	Describe processor organization, instruction execution, performance parameters, instruction sets, and addressing modes. (Cognitive Knowledge Level: Understand)
CO 3	Apply data representation methods and perform arithmetic operations using standard algorithms. (Cognitive Knowledge Level: Apply)
CO 4	Explain memory organization, cache and virtual memory concepts, and the basics of parallel processing architectures. (Cognitive Knowledge Level: Understand)
CO 5	Describe I/O organization, data transfer methods, and interrupt handling techniques. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	40	20	30
Understand	60	40	50
Apply		40	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 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 (7 hours)

Basic Structure of Computers

Functional units, basic operational concepts, bus structures. Memory locations and addresses - memory operations, instructions and instruction sequencing.

Basic processing unit

Fundamental concepts, instruction cycle, execution of a complete instruction, single bus and multiple bus organisation.

MODULE 2 (7 hours)

Performance of Computer

Processor clock, basic performance equation, clock rate, instruction set-RISC and CISC, compiler, performance measurement.

Addressing Modes based on RISC Architecture

Register addressing mode, absolute/direct addressing mode, immediate addressing mode, indirect addressing mode, index addressing mode, base with index, auto increment mode, auto decrement mode.

Pipelining: Introduction to pipelining- pipeline Hazards.

MODULE 3 (7 hours)

Data representation

Signed number representation, fixed and floating-point representations, character representation.

Computer Arithmetic

Integer addition, subtraction - booth algorithm, division - non-restoring and restoring techniques.

MODULE 4 (7 hours)

I/O Organisation

Characteristics of I/O devices, data transfer schemes - programmed controlled I/O transfer, interrupt controlled I/O transfer, Direct Memory Accessing (DMA) - modes.

Organisation of Interrupts

Interrupt types, servicing of multiple input/output devices - polling and daisy chaining schemes.

MODULE 5 (8 hours)

Memory Organization

Memory cells - basic organisation. Memory hierarchy - semiconductor RAMs. Memory system considerations - ROMs, content addressable memory, caches - cache performance, virtual memory.

Parallel Processing

Overview, supercomputers and GPUs - characteristics and applications, comparison with general-purpose CPUs.

Text Books

1. Hamacher C., Z. Vranesic and S. Zaky, *Computer Organization*, McGraw Hill, 5th ed., 2011.
2. William Stallings, *Computer Organization and Architecture: Designing for Performance*, Pearson, 9th ed., 2013.

Reference Books

1. Patterson D.A. and J. L. Hennessey, *Computer Organization and Design*, Morgan, Kauffmann Publishers, 5th ed., 2013.
2. Heuring V. P. and Jordan H. F., *Computer System Design and Architecture*, Addison Wesley, 2nd ed., 1997.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Basic Structure of Computers	7
1.1	Functional units, basic operational concepts	1
1.2	Bus structures	1
1.3	Memory locations and addresses	1
1.4	Memory operations	1
1.5	Instructions and instruction sequencing	1
	Basic processing unit	
1.6	Fundamental concepts, instruction cycle, execution of a complete instruction	1
1.7	Single bus and multiple bus organisation	1
	Module 2: Performance of Computer	7
2.1	Performance of Computer- Processor clock, basic performance equation, clock rate	1
2.2	Instruction set-RISC and CISC	1
2.3	Compiler, performance measurement	1
	Addressing Modes based on RISC Architecture	
2.4	Register addressing mode, absolute/direct addressing mode, immediate addressing mode	1
2.5	Indirect addressing mode, index addressing mode, base with index	1
2.6	Auto increment mode, auto decrement mode	1
	Pipelining	
2.7	Introduction to pipelining, pipeline Hazards	1
	Module 3: Data representation	7
3.1	Signed number representation	1
3.2	Fixed and floating-point representations	1
3.3	Character representation	1
	Computer Arithmetic	
3.4	Integer addition	1
3.5	Subtraction- Booth algorithm	1
3.6	Division - non-restoring techniques	1
3.7	Restoring techniques	1
	Module 4: I/O Organisation	7
4.1	Characteristics of I/O devices	1
4.2	Data transfer schemes	1
4.3	Programmed controlled I/O transfer, interrupt controlled I/O transfer	1
4.4	Direct Memory Accessing (DMA), modes	1
	Organisation of Interrupts	
4.5	Interrupt types	1

4.6	Servicing of multiple input/output devices	1
4.7	Polling and daisy chaining schemes	1
	Module 5: Memory Organization	8
5.1	Memory cells - basic organisation	1
5.2	Memory hierarchy - semiconductor RAMs	1
5.3	Memory system considerations - ROMs	1
5.4	Content addressable memory	1
5.5	Caches - cache performance	1
5.6	Virtual memory	1
	Parallel Processing	
5.7	Overview of parallel processing	1
5.8	Supercomputers and GPUs - characteristics and applications, comparison with general-purpose CPUs	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Define a computer system and list its functional units.
2. What is meant by instruction sequencing?
3. Explain the concept of a single bus organization with help of a diagram. Write the control sequence for the instruction ADD [R1],[R2].

Course Outcome 2 (CO 2)

1. Define computer performance. How is it measured?
2. Write the basic performance equation of a computer.
3. What is the role of a compiler in improving performance?

Course Outcome 3 (CO 3)

1. Explain 1's complement and 2's complement representation.
2. State any two differences between restoring and non-restoring division.
3. Explain ASCII character code.

Course Outcome 4 (CO 4)

1. What is an interrupt?
2. Differentiate between interrupt I/O and DMA.
3. What is an interrupt service routine?

Course Outcome 5 (CO 5)

1. Give the structure of the SRAM cell.
2. What is a supercomputer? State two key characteristics.
3. What is a GPU? Why is it suitable for parallel processing?

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: : B24EE3P16

Course Name: : COMPUTER ORGANIZATION AND ARCHITECTURE

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What is the role of the Control Unit in a computer?
2. Give the significance of instruction cycle.
3. How does pipelining improve performance?
4. What is the significance of addressing modes in computer architecture?
5. What is IEEE 754 floating-point representation?
6. Illustrate divide overflow with an example.
7. Differentiate between programmed I/O and interrupt-driven I/O.
8. Give the importance of interrupts in I/O interconnection.
9. What is the purpose of cache memory in a computer system?
10. What is a supercomputer? State two key characteristics.

PART B

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

11. (a) Explain various register transfer logics. (7 marks)
- (b) Illustrate the single bus organization of processor unit with the help of suitable diagrams. Explain, listing the control signals, how the following operations are handled in this organization. (a) Move (R6), R2 (b) Add (R4),(R3) (7 marks)

OR

12. Explain the concept of bus structures in a computer system. Discuss different types of buses and their functions. (14 marks)
13. (a) Explain memory addressing in a computer. How does addressing affect system performance? (7 marks)
- (b) Discuss the various addressing modes used in RISC architecture with suitable examples. (7 marks)

OR

14. Compare RISC and CISC architectures with respect to instruction set, execution, memory access, and performance. (14 marks)
15. (a) Explain the steps involved in floating-point addition and subtraction. How are rounding errors handled? (7 marks)
- (b) Give the logic used behind Booth's multiplication algorithm. (7 marks)

OR

16. Explain integer addition and subtraction using 2's complement representation with suitable examples. (14 marks)
17. (a) Explain the working of direct memory access (DMA) and its advantages over traditional I/O methods. (7 marks)
- (b) Describe different types of interrupts. (7 marks)

OR

18. (a) Explain the polling technique for servicing multiple I/O devices. (7 marks)
- (b) Explain the daisy chaining technique with a suitable diagram. (7 marks)
19. (a) Compare Asynchronous DRAMs and Synchronous DRAMs. (7 marks)
- (b) Briefly explain content addressable memory. (7 marks)

OR

20. (a) Describe general-purpose CPUs and their limitations for parallel computing. (7 marks)
- (b) Explain how GPUs overcome these limitations. (7 marks)



MINOR

B24EEM51	SYSTEMS THEORY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

The course aims to help students understand how to represent, analyze, and evaluate dynamic systems using state-space methods. It includes the study of state-space modeling, system analysis, stability of continuous and discrete systems, and the behavior of nonlinear systems using describing function and phase plane techniques. By the end of the course, students will be able to model and analyze different types of systems, assess their stability, and use modern control methods for system design and analysis.

Prerequisites

Nil

Course Outcomes

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

CO 1	Develop the state variable representation of physical systems. (Cognitive Knowledge Level: Understand)
CO 2	Analyse the performance of linear systems using state variable approach. (Cognitive Knowledge Level: Apply)
CO 3	Design state feedback controller for a given system. (Cognitive Knowledge Level: Apply)
CO 4	Analyse the performance of discrete time control systems using state variable approach. (Cognitive Knowledge Level: Apply)
CO 5	Explain the characteristics of nonlinear systems. (Cognitive Knowledge Level: Apply)

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	1	1	1			2
CO 2	3	3	3	2	3	1	1	1			2
CO 3	3	3	3	3	3	3	1	1			2
CO 4	3	2	3	2	3	3	1	1			2
CO 5	3	3	2	2	3	1	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	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 (10 hours)

State Space Representation of Systems

Introduction to state space and state model concepts, state equation of linear continuous time systems, matrix representation, features, examples of electrical circuits and DC servomotors, phase variable forms of state representation, diagonal canonical forms, similarity transformations to diagonal canonical form.

MODULE 2 (10 hours)

State Space Analysis of Continuous Time Control System

State transition matrix - properties of state transition matrix, computation of state transition matrix using Laplace transform and Cayley Hamilton methods, derivation of transfer functions from state equations, solution of time invariant systems, solution of time response of autonomous systems and forced systems..

MODULE 3 (8 hours)

State Space-Based Controller and Observer Design

State space design - controllability and observability from state space models - Kalman test, Gilbert test, principle of duality, pole zero cancellation, design of state feedback controllers from time domain specifications - pole placement technique, design of full order observers.

MODULE 4 (9 hours)

State Space Analysis of Discrete Time Control Systems

State space modelling of discrete time SISO system - phase variable form and diagonal canonical form representations, pulse transfer function from state matrix, computation of solution of state equation, state transition matrix – numerical problems from 2nd order systems.

MODULE 5 (8 hours)

Nonlinear Systems

Types and characteristics of nonlinear systems- Jump resonance, limit cycles and frequency entrainment, describing function method, analysis through harmonic linearization, determination of describing function of nonlinearities, application of describing function for stability analysis of autonomous system with a single nonlinearity - relay, dead zone, saturation.

Text Books

1. Nagrath I. J., *Systems Eng.*, New Age International, 7th ed., 2021.
2. Ogata K., *Modern Control Engineering*, Pearson Education India, 5th ed., 2015.
3. Gopal M., *Modern Control System theory*, New Age International publishers, 5th ed., 2024.
4. Khalil H. K., *Nonlinear Systems*, Pearson Education, 2019.

Reference Books

1. Kuo B. C., *Analysis and Synthesis of Sampled Data Systems*, Prentice Hall Publications, 2012.
2. Gibson J. E., *Nonlinear Automatic Control Engineering*, Mc Graw Hill, 1963.
3. Gopal M., *Control Systems Principles and Design*, Tata McGraw Hill, 4th ed., 2012.
4. Slotine J. E. and Weiping Li, *Applied Nonlinear Control*, Prentice-Hall, 1991.
5. Ogata K., *Discrete Time Control Systems*, Pearson Education, Asia, 2nd ed., 2015.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: State Space Representation of Systems	10
1.1	Introduction to state space and state model concepts	1
1.2	State equation of linear continuous time systems	1
1.3	Matrix representation, features	2
1.4	Examples of electrical circuits and dc servomotors	2
1.5	Phase variable forms of state representation	2
1.6	Similarity transformations to diagonal canonical form	2
	Module 2: State Space Analysis of Continuous Time Control System	10
2.1	State transition matrix - properties of state transition matrix	2
2.2	Computation of state transition matrix using Laplace transform and Cayley Hamilton methods	2
2.3	Derivation of transfer functions from state equations	2
2.4	Solution of time invariant systems	2
2.5	Solution of time response of autonomous systems and forced systems	2

	Module 3: State Space-Based Controller and Observer Design	8
3.1	State space design - controllability and observability from state space models	2
3.2	Kalman test	1
3.3	Gilbert test	2
3.4	Principle of duality, pole zero cancellation	2
3.4	Pole placement technique, design of full order observers	2
	Module 4: State Space Analysis of Discrete Time Control Systems	9
4.1	State space modelling of discrete time SISO system	1
4.2	Phase variable form representations	2
4.3	Diagonal canonical form representations	2
4.4	Pulse transfer function from state matrix	1
4.5	Computation of solution of state equation	1
4.6	State transition matrix, numerical problems from 2nd order systems	2
	Module 5: Nonlinear Systems	8
5.1	Types of nonlinear systems- characteristics of nonlinear systems- peculiar features like Jump resonance, Limit cycles and Frequency entrainment	1
5.2	Describing function Method: Analysis through harmonic linearisation	2
5.3	Determination of describing function of nonlinearities	1
5.4	Application of describing function for stability analysis of autonomous system with single nonlinearity, relay	2
5.5	Dead zone and saturation only	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Derive the state model of an armature controlled DC servo motor.
2. Obtain the phase variable representation for the system with

$$G(s) = \frac{2s^2 + s + 3}{s^3 + 6s^2 + 11s + 6}$$

3. Problems on deriving the state model of a given electrical circuit.
4. Problems on the conversion of Phase variable form to Canonical form.

Course Outcome 2 (CO 2)

1. Determine the transfer function for the system with the state model:

$$\dot{X} = \begin{bmatrix} -2 & 1 \\ -3 & -2 \end{bmatrix} x + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u, \quad [y] = [1 \quad 1] x$$

2. Derivation of transfer functions from state equations.
3. Find the state transition matrix using Cayley-Hamilton theorem for the system matrix given below.

$$[A] = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$$

Course Outcome 3 (CO 3)

1. Design a state feedback controller for the following system such that the closed loop poles are placed at: $-1 \pm j2$ and -12 .

$$\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & -1 & 2 \\ 0 & -1 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

2. Determine the controllability and observability of a system using Gilbert test and Kalman test.
3. Design of full order observers.

Course Outcome 4 (CO 4)

1. Obtain the pulse transfer function.
2. Solution of state transition matrix for discrete time system.
3. Obtain the phase variable form and diagonal canonical form representation of discrete system.

Course Outcome 5 (CO 5)

1. Explain the linearization concept and assumptions made referred to describing function analysis.
2. With suitable characteristics explain the jump resonance phenomena.
3. Differentiate between linear and nonlinear systems referred to: i) frequency response, ii) sustained oscillations.
4. Identify and explain the type of singular points for the following two systems:

i) $\dot{X} = \begin{bmatrix} 0 & 1 \\ -2 & 3 \end{bmatrix} X$ ii) $\dot{X} = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix} X$

MODEL QUESTION PAPER

QP CODE:

Pages: 4

Reg.No.:

Name:

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),
KOTHAMANGALAM

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: : B24EEM51

Course Name: : SYSTEMS THEORY

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define the terms (i) state variables (ii) phase variables and (iii) state space.
2. Obtain the diagonal canonical representation for the system with the transfer function

$$T(s) = \frac{s + 2}{s^2 + 0.7s + 0.1}$$

3. State and prove any three properties of state transition matrix.
4. Determine the transfer function for the system with state model:

$$\dot{x} = \begin{bmatrix} -2 & 1 \\ 0 & -2 \end{bmatrix} x + \begin{bmatrix} 2 \\ 0 \end{bmatrix} u, \quad y = \begin{bmatrix} 1 & 0 \end{bmatrix} x.$$

5. Define controllability and explain Kalman's method for determining controllability.
6. With necessary equations, explain duality principle.
7. A discrete time system is described by the difference equation

$$y(k + 3) + 3y(k + 2) + 2y(k + 1) + y(k) = 5u(k)$$

8. Explain the properties of state transition matrix of discrete time systems.
9. Obtain the describing function of deadzone non-linearity.

10. With suitable characteristics explain the jump resonance phenomena in nonlinear systems.

PART B

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

11. (a) From basics, derive the state model of an armature controlled dc motor. (7 marks)

(b) Differential equation of the system is given by,

$$\frac{d^3y}{dt^3} + 6 \frac{d^2y}{dt^2} + 11 \frac{dy}{dt} + 6y + u = 0$$

where, y is the output and u is the input. Derive the state model of the system using phase variables. (7 marks)

OR

12. (a) Determine the diagonal canonical representation for the system:

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix} u; \quad [y] = [1 \ 0 \ 0] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

(10 marks)

(b) Explain any four advantages of state model as compared to transfer function model. (4 marks)

13. (a) Obtain the unit step response y(t) of the system

$$\dot{x} = \begin{bmatrix} -1 & 0 \\ -2 & -3 \end{bmatrix} x + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u, \quad [y] = [1 \ 1] x$$

(7 marks)

(b) State equation of a system is given below. Compute the state transition matrix using Laplace transform method. Also, compute the solution of the given state equation if the initial state vector is X(0).

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}, \quad x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

(7 marks)

OR

14. (a) Determine the state transition matrix for the system with state model:

$$[\dot{x}] = \begin{bmatrix} -1 & 1 \\ 1 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

(7 marks)

- (b) Find the state transition matrix using Cayley-Hamilton theorem for the system matrix given below.

$$A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$$

(7 marks)

15. (a) Using Kalman's method, check the observability of the system given below.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -3 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u; \quad y = \begin{bmatrix} 40 & 10 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

(6 marks)

- (b) Design the observer feed back gain matrix for the desired eigen values at -4, -3±j1 for the state model of the system given below.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 1 & 2 & 0 \\ 3 & -1 & 1 \\ 0 & 2 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 2 \\ 1 \\ 1 \end{bmatrix} u; \quad y = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

(8 marks)

OR

16. Consider a linear system described by the transfer function

$$\frac{Y(Z)}{U(Z)} = \frac{10}{s(s+1)(s+2)}$$

Design a feedback controller with a state feedback so that the closed loop poles are placed at -2, -1±j1. (14 marks).

17. A discrete time system is given by,

$$y(k+2) + 5y(k+1) + 6y(k) = u(k)$$

where, y is the output and u is the input. Assume zero initial conditions and the sampling period as 1 second. (i) Derive the state model of the system in Jordan canonical form (ii) Draw the block diagram of the state model and (iii) Compute the state transition matrix.

(14 marks)

OR

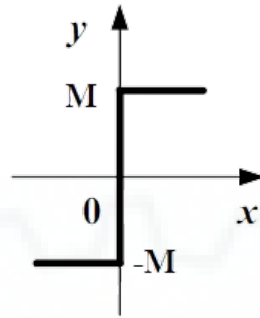
18. (a) A discrete time system has the transfer function :

$$\frac{Y(Z)}{U(Z)} = \frac{4Z^3 - 12Z^2 + 13Z - 7}{(Z-1)^2(Z-2)}$$

(7 marks)

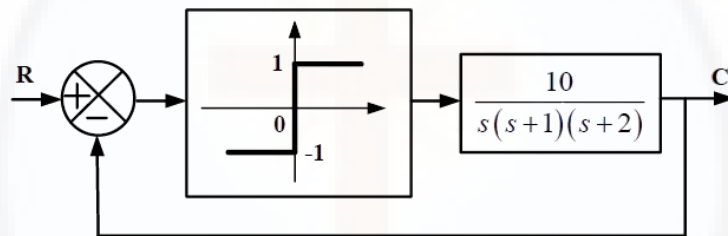
- (b) Determine the state model of the system in Jordan Canonical form. (7 marks)

19. (a) Derive the describing function of ideal relay non-linearity given below.



(6 marks)

- (b) Determine the frequency and nature of the limit cycle for the unity feed back system given below.



(8 marks)

OR

20. (a) Obtain the describing function of relay with dead zone nonlinearity (10 marks)
(b) Explain the linearization concept and assumptions made referred to Describing Function analysis. (4 marks)

B24EEM52	SOLID STATE POWER CONVERSION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course aims to provide a foundational understanding of solid state power conversion and its role in efficient electrical energy processing across modern engineering applications. It covers the characteristics of power semiconductor devices and the operation of rectifiers, inverters, DC–DC converters, and AC–AC converters used in power electronic systems. By the end of the course, students will be able to understand, analyze, and apply suitable power conversion techniques to evaluate and improve the performance of practical power electronic systems.

Prerequisites

Nil

Course Outcomes

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

CO 1	Analyze the characteristics of power semiconductor devices, and illustrate their switching principles. (Cognitive Knowledge Level: Understand)
CO 2	Analyze the operation and performance of single-phase and three-phase phase-controlled rectifiers with various loads in continuous conduction modes. (Cognitive Knowledge Level: Apply)
CO 3	Analyze the operation of single-phase and three-phase inverters and compare different PWM techniques. (Cognitive Knowledge Level: Apply)
CO 4	Apply the principles of chopper circuits and switching regulators (buck, boost, buck-boost) to Interpret the circuit waveforms in continuous conduction mode. (Cognitive Knowledge Level: Apply)
CO 5	Classify different types of AC–AC converters and analyze their performance in different applications. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

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

Solid State Devices and Solid State Power Conversion

Role of power electronics, introduction to power conversion - need for power conversion, solid state devices - scope and application, static characteristics and specifications of solid state devices - power diodes, SCR, power MOSFET and IGBT, turn-on methods of SCR, series and parallel operation of SCRs, wide band gap devices - GaN, SiC, advantages over silicon devices, properties, general applications.

MODULE 2 (9 hours)

Phase Controlled Rectifiers

Single-phase – half-wave controlled rectifiers, fully-controlled converters - R, RL, RLE loads - continuous operation, Average and RMS output voltage, effect of firing angle on waveform and power delivered, use of freewheeling diode for inductive loads Three-phase Converters - half-wave controlled rectifier, full-wave fully controlled converters - R and RL loads, continuous current operation.

Use simulation software like MATLAB/Simulink to simulate converters with R, RL and RLE loads. (Assignment/ Tutorial only)

MODULE 3 (9 hours)

Voltage Source Inverters

Single-phase half-bridge inverters and full-bridge inverters - square wave operation, Pulse Width Modulation (PWM) - single pulse and multiple pulse modulation, sinusoidal PWM, advantages. Three-phase inverters - 120°, 180° conduction modes.

Use simulation software like MATLAB/Simulink to simulate inverters. (Assignment/ Tutorial only)

MODULE 4 (10 hours)

DC-DC Converters

Choppers - step-down and step-up choppers, single-quadrant, two-quadrant, and four-quadrant choppers. Switching regulators - buck, boost, and buck-boost, operation with continuous conduction mode, waveforms, concept of duty cycle and its impact on output, applications.

Use simulation software like MATLAB/Simulink to simulate Buck, Boost and Buck-Boost converters. (Assignment/ Tutorial only)

MODULE 5 (8 hours)

AC-AC Converters

AC-AC conversion - importance in real-world applications, classification, AC Voltage Controllers (ACVC) - single-phase full-wave ACVC with R and RL loads, waveforms, RMS output voltage. Cycloconverters - single-phase cycloconverters, principle of operation, types - mid-point and bridge type cycloconverters, applications.

Use simulation software like MATLAB/Simulink to simulate AC-AC converters with R and RL loads. (Assignment/ Tutorial only)

Text Books

1. Muhammad H. Rashid, *Power Electronics: Circuits, Devices and Applications*, Pearson, 4th ed., 2014.
2. Daniel W. Hart, *Power Electronics*, McGraw Hill, 1st ed., 2011.
3. P.S. Bimbhra, *Power Electronics*, 5th ed., Khanna Publishers, 2022.
4. Jayant Baliga, *Fundamentals of Power Semiconductor Devices*, Springer, 2nd ed., 2018.
5. P.C Sen, *Power Electronics*, Tata McGraw-Hill Education, Revised ed., 2019.

Reference Books

1. Ned Mohan, Tore M. Undeland & William P. Robbins, *Power Electronics: Converters, Applications and Design*, Wiley, 4th ed., 2023.
2. Robert W. Erickson & Dragan Maksimović, *Fundamentals of Power Electronics*, Springer, 3rd ed., 2020.
3. John G. Kassakian, Martin F. Schlecht & George C. Verghese, *Principles of Power Electronics*, Cambridge University Press, 2nd ed., 2023.
4. Muhammad H. Rashid, *Power Electronics Handbook*, Academic Press, 5th ed., 2022.
5. Sanjaya Maniktala, *Switching Power Supplies A-Z*, Elsevier/Newnes, 3rd ed., 2020.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Solid State Devices and Solid State Power Conversion	9
1.1	Role of power electronics, introduction to power conversion - need for power conversion	1
1.2	Solid state devices - scope and application, static characteristics and specifications of solid state devices - power diodes	2
1.3	Static characteristics and specifications of solid state devices - SCR- turn- on methods of SCR	1
1.4	Series and parallel operation of SCRs	1
1.5	Static characteristics and specifications of solid state devices -power MOSFET & IGBT	2
1.6	Wide band gap devices - GaN, SiC, advantages over silicon devices, properties, general applications	1
1.7	Concepts of Sourcing, sinking, fan-in, fan-out	1
	Module 2: Phase Controlled Rectifiers	9
2.1	Single-phase half-wave controlled rectifiers	1
2.2	Fully-controlled converters - R Load- continuous operation, Average and RMS output voltage, effect of firing angle on waveform and power delivered	2
2.3	Fully-controlled converters - RL, RLE loads - continuous operation, average and RMS output voltage, effect of firing angle on waveform and power delivered- use of freewheeling diode for inductive loads	2
2.4	Three-phase Converters - half-wave controlled rectifier	1
2.5	Full-wave fully controlled three-phase converters with R Load- continuous current operation	1
2.6	Full-wave fully controlled three-phase converters with RL Load- continuous current operation	2
	Module 3: Voltage source Inverters	9
3.1	Single-phase half-bridge inverters	1
3.2	Full-bridge inverters- square wave operation	1
3.3	Pulse Width Modulation (PWM) - single pulse modulation	2
3.4	Multiple pulse modulation	1
3.5	Sinusoidal PWM, advantages	1
3.6	Three-phase inverters - 120°, 180° conduction modes	2
3.7	Active filters, state variable filters	1
	Module 4: DC-DC Converters	10
4.1	Choppers - step-down and step-up choppers	1
4.2	Single-quadrant, two-quadrant choppers	1

4.3	Four-quadrant choppers	1
4.4	Switching regulators - buck DC - DC Converter - operation with continuous conduction mode, waveforms, concept of duty cycle and its impact on output, applications	2
4.5	Boost DC -DC Converter- operation with continuous conduction mode, waveforms, concept of duty cycle and its impact on output, applications	1
4.6	Design Problem on Buck and Boost converters	2
4.7	Buck-boost DC -DC Converter, operation with continuous conduction mode, waveforms, concept of duty cycle and its impact on output, applications	2
	Module 5: AC-AC Converters	8
5.1	AC-AC conversion - importance in real-world applications, classification	1
5.2	AC Voltage Controllers (ACVC) - single-phase full-wave ACVC with R load- waveforms, RMS output voltage	2
5.3	AC Voltage Controllers (ACVC) - single-phase full-wave ACVC with RL load- waveforms, RMS output voltage	2
5.4	Cycloconverters - single-phase cycloconverters, principle of operation	1
5.5	Mid-point and bridge type cycloconverters, applications	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the static and dynamic characteristics of an SCR and discuss how these characteristics influence its switching behavior in power converters.
2. Compare the switching performance of power MOSFETs and IGBTs for medium- and high-power applications.
3. Analyze the turn-on and turn-off mechanisms of SCRs and explain their significance in controlled rectifier circuits.
4. Explain why wide bandgap devices such as SiC and GaN are preferred over silicon devices in high-frequency and high-temperature power conversion applications.

Course Outcome 2 (CO 2)

1. Derive and calculate the average and RMS output voltages of a single-phase fully controlled rectifier supplying an R load for a given firing angle.

2. Calculate the output voltage of a three-phase controlled rectifier operating under continuous current mode and interpret the results for different firing angles.
3. Analyze the effect of firing angle variation on output voltage, current waveform, and power factor in controlled rectifiers.
4. Explain how load characteristics (R, RL, RLE) affect the performance of single-phase and three-phase controlled rectifiers.

Course Outcome 3 (CO 3)

1. Compare the operation of single-phase half-bridge and full-bridge inverters with respect to output voltage levels and harmonic content.
2. Analyze the effect of square-wave operation on inverter output waveform quality and system efficiency.
3. Explain the working principle of sinusoidal PWM and evaluate its advantages over single-pulse and multiple-pulse modulation techniques.
4. Compare and analyze different PWM strategies in terms of harmonic reduction, switching losses, and control flexibility.

Course Outcome 4 (CO 4)

1. Explain and evaluate the operation of buck, boost, and buck–boost converters in continuous conduction mode based on duty cycle and voltage gain.
2. Analyze the effect of duty cycle variation on output voltage and current ripple in a DC–DC converter.
3. Compare single-quadrant, two-quadrant, and four-quadrant chopper configurations and justify their suitability for different applications.

Course Outcome 5 (CO 5)

1. Describe the operating principle of a single-phase AC voltage controller supplying R and RL loads, and illustrate the corresponding voltage and current waveforms.
2. Explain the working of a single-phase cycloconverter and describe how low-frequency AC output is synthesized from a fixed-frequency AC input.
3. Compare and justify the selection of AC voltage controllers or cycloconverters for applications such as heating control, speed control of AC motors, or low-frequency power supplies.
4. Compare mid-point and bridge cycloconverters

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: : B24EEM52

Course Name: : SOLID STATE POWER CONVERSION

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the need for power conversion in modern electrical systems and describe the role of power electronics in this context.
2. What are wide band gap devices? Give any one example.
3. Illustrate how the firing angle influences the output voltage of a single-phase fully controlled converter with an R-load.
4. For an RL load in a single-phase controlled rectifier, explain the need for a freewheeling diode (FWD).
5. Differentiate between single-phase half-bridge and full-bridge inverters with respect to circuit structure and output waveforms.
6. Analyze how sinusoidal PWM improves the quality of inverter output compared to square-wave operation.
7. Explain the operating principle of a buck converter in Continuous Conduction Mode (CCM) and state the influence of duty cycle on output voltage.
8. Apply the concept of chopper classifications to distinguish between single-quadrant and four-quadrant choppers with examples.
9. Describe the operating principle of a single-phase full-wave AC voltage controller with an RL load.

10. Explain the working principle of a single-phase mid-point cycloconverter.

PART B

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

11. Illustrate the constructional features, static characteristics and switching mechanisms of Silicon-Controlled Rectifiers (SCRs). (14 marks)

OR

12. (a) With neat sketches, explain the series and parallel operation of SCRs, and state the need for such configurations. (7 marks)
- (b)) Evaluate the role of power semiconductor devices in modern solid state power conversion systems with two real-world examples. (7 marks)
13. (a) Analyze the performance of a single-phase fully controlled rectifier supplying an RL load and discuss the effect of load inductance on commutation. (7 marks)
- (b) Compare the performance of single-phase and three-phase controlled rectifiers in industrial applications, highlighting advantages and limitations. (7 marks)

OR

14. (a) Derive the expression for the average output voltage of a single-phase full converter feeding an RLE load under continuous conduction. (7 marks)
- (b) Explain with waveforms the operation of a three-phase half-wave controlled rectifier supplying an R-load. (7 marks)
15. (a) Explain the operation of a single-phase full-bridge inverter using unipolar switching. Provide appropriate waveforms. (7 marks)
- (b) With diagrams explain 180° conduction modes of a three-phase inverter. (7 marks)

OR

16. (a) Discuss single pulse and multiple pulse modulation techniques used in inverters. Include relevant waveform sketches. (7 marks)

- (b) Evaluate the advantages of sinusoidal PWM over other PWM strategies in terms of harmonic reduction and voltage control.

(7 marks)

17. A Buck converter is required to step down 24 V to 12 V supplying 2 A load current. Design the converter by determining: i) Duty cycle, ii) Inductor value for ripple current $\leq 20\%$ of load current iii) Output capacitor (for voltage ripple $\leq 1\%$). (14 marks)

OR

18. Discuss the operation of a four-quadrant chopper and show how it enables bidirectional current and voltage flow.

(14 marks)

19. Explain the operation of a single-phase full-wave AC Voltage Controller (ACVC) feeding R and RL loads, highlighting the differences in their waveforms and the method of determining RMS output voltage. (14 marks)

OR

20. (a) Describe the principle of operation of a single-phase cycloconverter, and illustrate how the output frequency is synthesized from the input waveform.

(7 marks)

- (b) Compare mid-point and bridge-type cycloconverters in terms of circuit arrangement, performance, and typical applications, emphasizing the conditions under which each topology is preferred. (7 marks)

B24EEM53	POWER SYSTEM OPERATION AND CONTROL	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course aims to equip the students with an understanding of the fundamentals of Electrical Power System and its Operations and Control. The course provides an overview of various control techniques and scheduling problems for stable and economic load dispatch. The course equips the students to apply the acquired knowledge to analyse and develop computer aided systems for the efficient operation and control of Electrical Power Systems.

Prerequisites

Basics of Electrical Engineering/Fundamentals of Electrical Engineering

Course Outcomes

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

CO 1	Understand and analyse the characteristics for the economic operation of power system. (Cognitive Knowledge Level: Understand)
CO 2	Understand and apply the scheduling of hydrothermal power plants along with the basic concepts of load forecasting and dispatching. (Cognitive Knowledge Level: Apply)
CO 3	Develop power system models for the load frequency control and analysis. (Cognitive Knowledge Level: Apply)
CO 4	Apply various reactive power control strategies for power system stability. (Cognitive Knowledge Level: Apply)
CO 5	Understand and analyze economic interchange of power and energy between interconnected utilities and the need of computer aided control in power systems. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	2	1	1	2	1	1	1	1	2
CO 2	3	3	2	1	1	2	1	1	1	1	2
CO 3	3	3	2	1	1	2	1	1	1	1	2
CO 4	3	3	2	1	1	2	1	1	1	1	2
CO 5	3	3	1	1	1	2	1	1	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	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	15 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)

Economic Load Dispatch and Unit Commitment

Economic Operation of Power Systems, characteristics of power generation unit, input-output characteristics, cost curve, incremental fuel cost curve, heat rate curve, incremental efficiency.

Economic operation - distribution of load between units within a plant, transmission loss as a function of plant generation, distribution of load between plants, method of computing penalty factors, and loss coefficients.

Unit commitment - Introduction, constraints - spinning reserve, thermal and hydro constraints, dynamic scheduling.

MODULE 2 (8 hours)

Hydrothermal Scheduling

Hydroelectric power plant models, scheduling problems, short term hydrothermal scheduling problem - gradient approach, hydro units in series, pumped storage hydro plants, dynamic programming solution to hydro thermal scheduling problem. Basic concepts of load dispatching, load forecasting, load shedding and islanding.

MODULE 3 (9 hours)

Real Power - Frequency Control

Necessity of keeping frequency constant, speed governing mechanisms, turbine load model, generator load model, speed load characteristics. Control area – Single area control, block diagram representation of an isolated power system, steady state analysis, load frequency control of 2-area system, tie-line frequency bias control.

MODULE 4 (10 hours)

Load Compensation

Load compensation - objectives and specifications, characteristics impedance of compensated transmission lines, shunt compensators, series compensators, unified power flow controller, voltage stability and voltage collapse.

Reactive Power - Voltage Control

Necessity of Voltage control, generation and absorption of reactive power, location of voltage control equipment, basics of reactive power control - Automatic Voltage Regulator (AVR), methods of voltage control - excitation control, shunt capacitors and reactors, series capacitors, tap changing transformers, booster transformers, synchronous condensers, SVC - TCR and TSC, STATCOM.

MODULE 5 (9 hours)

Computer-Aided Control of Power Systems

Need for computer control of power systems, concept of energy control centers and functions, PMU, system monitoring, data acquisition and controls - SCADA and EMS functions.

Interchange of Power and Energy

Economy interchange between interconnected utilities, inter-utility economy energy evaluation, capacity interchange, diversity interchange, energy banking, emergency power interchange, inadvertent power exchange, power pools, transmission effects and issues. Introduction to Power system security – factors affecting power system security.

Text Books

1. J. Wood and B. F. Wollenberg, *Power Generation, Operation and Control*, John Wiley & Sons, 3rd ed., New York, 2013.
2. S. Sivanagaraju, G. Sreenivasan, *Power System Operation and Control*, Pearson, 2010.
3. Abhijit Chakrabarti, Sunita Halder, *Power System analysis Operation and Control*, PHI learning private limited, 3rd ed., 2011.

Reference Books

1. P. Kundur, *Power System Stability and Control*, McGraw Hill, 2nd ed., 2022.
2. A. Chakrabarti, D. P. Kothari, A. K. Mukhopadhyay, Abhinandan De, *Introduction to Reactive Power Control and Voltage Stability in Power Transmission Systems*, Prentice Hall India Pvt.Ltd, 2010.
3. P.S.R. Murty, *Operations and Control in Power systems*, BS Publications, 2nd ed., 2011.
4. Vijay Vittal, James D. McCalley, Paul M. Anderson, and A.A. Fouad, *Power System Control and Stability*, John Wiley & Sons, 3rd ed., 2019.
5. William D. Stevenson, *Elements of Power System Analysis*, McGraw Hill Higher Education, 4th ed., 1982.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Economic Load Dispatch and Unit Commitment	9
1.1	Economic Operation of Power Systems, characteristics of power generation unit, input-output characteristics	1
1.2	cost curve, incremental fuel cost curve, heat rate curve, incremental efficiency, numerical problems	2
1.3	Economic operation - distribution of load between units within a plant, transmission loss as a function of plant generation	2
1.4	Distribution of load between plants, method of computing penalty factors, and loss coefficients, numerical problems	2
1.5	Unit commitment - Introduction, constraints - spinning reserve, thermal and hydro constraints, dynamic scheduling	2
	Module 2: Hydrothermal Scheduling	8
2.1	Hydroelectric power plant models, Scheduling problems	2
2.2	short term hydrothermal scheduling problem - gradient approach, hydro units in series, pumped storage hydro plants	2
2.3	Dynamic programming solution to hydro thermal scheduling problem	2
2.4	Basic concepts of load dispatching, load forecasting, load shedding and islanding	2
	Module 3: Real Power - Frequency Control	9
3.1	Necessity of keeping frequency constant, speed governing mechanisms	1
3.2	turbine load model, generator load model, speed load characteristics	2
3.3	Control area – Single area control, block diagram representation of an isolated power system	2
3.4	steady state analysis, load frequency control of 2-area system, numerical problems	2
3.5	tie-line frequency bias control	2
	Module 4: Load Compensation	10
4.1	Load compensation - objectives and specifications	1
4.2	characteristics impedance of compensated transmission lines, shunt compensators, series compensators	2
4.3	unified power flow controller, voltage stability and voltage collapse	2
	Reactive Power - Voltage Control	
4.4	Necessity of Voltage control, generation and absorption of reactive power	1

4.5	location of voltage control equipment, basics of reactive power control - Automatic Voltage Regulator (AVR)	2
4.6	methods of voltage control - excitation control, shunt capacitors and reactors, series capacitors, tap changing transformers, booster transformers, synchronous condensers, SVC - TCR and TSC, STATCOM	2
	Module 5: Computer-Aided Control of Power Systems	9
5.1	Need for computer control of power systems, concept of energy control centers and functions, PMU, system monitoring	2
5.2	data acquisition and controls - SCADA and EMS functions	2
	Interchange of Power and Energy	
5.3	Economy interchange between interconnected utilities, inter-utility economy energy evaluation	1
5.4	capacity interchange, diversity interchange, energy banking, emergency power interchange, inadvertent power exchange, power pools, transmission effects and issues	2
5.5	Introduction to Power system security – factors affecting power system security	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain incremental fuel cost curve.
2. For the economic dispatch of two generating units within a single plant, neglecting transmission losses, what is the necessary condition for minimum total operating cost.
3. In the context of Economic Dispatch including transmission losses, what does the Penalty Factor L_i for a generating plant represent.

Course Outcome 2 (CO 2)

1. A Pumped Storage Hydro Plant (PSHP) is primarily utilized in a power system for what economic purpose.
2. Explain Gradient approach in Short Term Hydrothermal Scheduling.
3. Define terms Load shedding and Islanding.

Course Outcome 3 (CO 3)

1. A thermal generator operates with a speed regulation (droop) of $R=5 \text{ Hz/p.u.MW}$. If the system frequency drops by 0.1 Hz due to a sudden load increase, how much will the generator's power output increase (in p.u. MW) due to its primary speed governing action.
2. Explain the relation between Frequency and system Stability.
3. Explain the significance of frequency control in multi area power system.

Course Outcome 4 (CO 4)

1. Explain how load compensation enhances power transfer capability.
2. Compare Series and Shunt compensation methods.
3. Describe the relation between Voltage and Reactive power.

Course Outcome 5 (CO 5)

1. Explain the need of computer aided power systems in terms of power system security.
2. Explain the concept of capacity interchange between inter connected utilities.
3. Describe the need for power system security.

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: : B24EEM53

Course Name: : POWER SYSTEM OPERATION AND CONTROL

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the physical reason why the Heat Rate curve typically shows a minimum value near the mid-to-high end of the unit's operating range, rather than at its minimum output.
2. Define and explain the physical necessity of the following constraints for a thermal unit: a) Minimum Up Time (MUT) b) Minimum Down Time (MDT).
3. Explain Pumped storage hydro plant.
4. Describe the input-output characteristic of a thermal unit.
5. State and explain three distinct technical reasons why maintaining the system frequency constant is absolutely necessary for the safe, reliable, and economic operation of a large interconnected power system.
6. Define the Speed-Load Characteristic of a synchronous generator operating in parallel with the grid.
7. State the three main objectives of Load Compensation in a modern transmission system.
8. Define the Characteristic Impedance Z_0 and Surge Impedance Loading (SIL) of a transmission line.
9. Differentiate clearly between the primary functions of SCADA (Supervisory Control and Data Acquisition) and EMS (Energy Management System).

10. Define Economy Interchange between two interconnected utility areas.

PART B

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

11. Two generating units have fuel cost functions $F_1(P_1)$ and $F_2(P_2)$. The incremental fuel costs are $IFC_1 = 0.01P_1 + 25$ and $IFC_2 = 0.015P_2 + 20$ (Rs/MWh). The total load to be met is $P_D = 500$ MW. Determine the optimal schedule (P_1 , P_2) and the resulting savings in total hourly fuel cost if the load is dispatched economically, compared to an equal sharing of the load. (14 marks)

OR

12. Explain the two primary types of constraints imposed by hydro units when considering a short-term unit commitment schedule for a hydro-thermal system. Why can the scheduling of hydro units sometimes be treated separately from the commitment of thermal units, and what approximation is usually made in this decoupled approach. (14 marks)
13. Define Load Forecasting and classify it based on the forecasting horizon (Short-Term, Medium-Term, Long-Term). Explain why accurate Short-Term Load Forecasting (STLF) is essential for the effective operation of an Economic Load Dispatch (ELD) and a Hydrothermal Scheduling program. List two key factors that significantly influence STLF accuracy. (14 marks)

OR

14. (a) Define power system islanding. Describe two critical operational hazards associated with an unplanned islanding event, particularly concerning the safety of utility personnel and the possible damage to grid-connected distributed generation (DG) equipment. (8 marks)
- (b) Explain the necessity of Under-Frequency Load Shedding (UFLS) in a power system. (6 marks)
15. (a) Define the Load Damping Constant D or Load-Frequency Constant. (4 marks)
- (b) Given a single isolated area system with a total generating capacity of 5000 MW and an average speed regulation R of 4%, and assuming the load-frequency dependency D is 1% of the total capacity per Hz change, calculate the steady-state frequency drop (in Hz) when a step load of 100 MW is suddenly applied. (10 marks)

OR

16. (a) Explain how the tie-line power flow P_{tie} depends on the difference between the integrated frequencies of the two areas f_1 and f_2 . (6 marks)

- (b) With the aid of a simplified diagram, identify the three main functional components of a classic speed governing mechanism. Explain the role of the Hydraulic Amplifier (Servomotor) in the control loop. (8 marks)
17. (a) Explain how shunt compensation fundamentally differs from series compensation and specify which type primarily addresses the reduction of line reactance. (6 marks)
- (b) Define the terms Voltage Stability and Voltage Collapse. Explain the role of reactive power reserve in maintaining voltage stability. Illustrate the concept using a conceptual P-V curve and mark the point that represents the stability limit, beyond which voltage collapse is imminent. (8 marks)

OR

18. (a) Differentiate between an Off-Load Tap Changer (OLTC) and an On-Load Tap Changer (OLTC) used in power transformers. (10 marks)
- (b) State one major advantage and one major disadvantage of using it for reactive power management compared to a STATCOM. (4 marks)
19. (a) Explain the necessity of shifting from manual to computer control of power systems. (4 marks)
- (b) Introduce the concept of Power System Security. List and briefly explain three major factors that directly affect the overall security of a power system. (10 marks)

OR

20. (a) Distinguish between Diversity Interchange and Energy Banking as forms of inter-utility power exchange. Give a practical scenario for each type of interchange, explaining the economic or resource advantage gained by the participating utilities. (8 marks)
- (b) Differentiate between Capacity Interchange and Emergency Power Interchange agreements between utilities. (6 marks)

The logo of Mar Athanasius College of Engineering is a large, faint watermark in the background. It features a circular gear-like border. Inside the circle is a light blue circle containing a large orange cross. Below the cross are green hills and a pink book. A yellow banner at the bottom of the logo contains the text "KNOWLEDGE IS POWER".

HONOURS

B24EEH51	SIMULATION OF ELECTRIC SYSTEMS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

Numerical simulation using digital computing is essential in modern electrical engineering analysis and design. This honours course provides a strong theoretical foundation for numerical modelling and simulation of electrical engineering systems. It helps students understand the computational principles behind simulation tools and apply them in real engineering tasks. The course also introduces industry-standard environments such as MATLAB and SPICE to prepare students for advanced research and professional work.

Prerequisites

Circuits and Networks, Electronic Circuits I, Electronic Circuits II, Ordinary Differential Equations and Transforms.

Course Outcomes

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

CO 1	Formulate circuit equations using Nodal Analysis, Modified Nodal Analysis (MNA), and Sparse Tableau Approaches for both linear and non-linear systems. (Cognitive Knowledge Level: Apply)
CO 2	Apply numerical integration techniques to electrical circuit simulations, and to understand practical considerations. (Cognitive Knowledge Level: Apply)
CO 3	Create SPICE-based circuit simulation tools by analyze, and interpret SPICE circuit files, component models, and simulation directives for various types of analyses. (Cognitive Knowledge Level: Analyze)
CO 4	Implement and solve ordinary differential equations using MATLAB programming. (Cognitive Knowledge Level: Apply)
CO 5	Model and solve ordinary differential equations using MATLAB Simulink. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	1	2	1	1	1	1			1
CO 2	3	3	2	2	1	1	1	1			1
CO 3	3	3	3	2	2	2	1	1	1	1	1
CO 4	3	3	2	2	2	2	1	1	1	1	1
CO 5	3	3	2	2	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	20	20	20
Understand	40	40	40
Apply	40	30	30
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/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)

Formulation for Circuit Simulation

Types of simulation problems - DC simulation, transient simulation, AC simulation. Digital circuit simulation - sensitivity analysis, noise analysis, examples. Nodal analysis - general rules to form the admittance matrix, sample problems. Modified Nodal Analysis (MNA) - general rules to form the admittance matrix, sample problems. Sparse Tableau Approach (STA) - formulation of STA matrix, features and comparison with MNA approach, formulation examples. Non-linear circuits - application of the Newton-Raphson method, general procedure for n^{th} order system of equations, formulation of Jacobian matrix, examples. Resources required for simulation - computation time. Convergence issues - practical limits due to finite precision, damping.

MODULE 2 (10 hours)

Transient Simulation

Introduction to transient simulation - discretization of time, accuracy, stability, explicit and implicit schemes. Methods of transient simulation - forward Eulers method, backward Eulers method, trapezoidal method. Local Error (LE), Local Truncation Error (LTE) and Global Error (GE). Stiff systems - adaptive step-size. Equivalent circuit approach - RC circuit, buck converter. Practical aspects in choosing numerical methods - undamped oscillations, ringing, global error in switching circuits, round-off error, assessment of accuracy, issue of singular matrix.

MODULE 3 (8 hours)

Introduction to SPICE

Types of simulation tools - circuit simulation tools (SPICE), equation solvers (MATLAB/S-cilab/Octave), features, similarities and differences. Circuit simulation using SPICE - writing SPICE circuit files, SPICE syntax. SPICE directives - dot commands: .END, .FUNC, .NET, .OPTIONS, .OP, .PARAM, .TRAN, .DC, .STEP, .IC, .MEASURE, .FOUR, .NOISE, .TEMP, .WAVE, .MODEL, .SUBCKT, .LIB, .INC, .ENDS. Developing circuit files- CE amplifiers, passive linear/non-linear circuits. Developing component models- BJTs, MOSFETs.

Simulation demonstration with simple circuits (only for practice/assignments).

MODULE 4 (9 hours)

Introduction to Equation Solver Tools

Introduction to scripting using MATLAB®: language constructs, basic arithmetic operations, basic operators, special characters, variables, and arrays. complex numbers, basics of arrays. Control structures - conditional looping - for loop, while loop, switch-case, otherwise, break -return, functions. Numerical integration - ode23, ode23t, ode45. Examples - user-written functions to solve ODEs to implement the algorithms BE, FE, and TRZ only. Application examples.

MODULE 5 (9 hours)

Visual Modelling

Introduction to Simulink, developing causal simulation diagrams - fundamental blocks, first-order/second-order circuits, separately excited DC Motor. Non-linear examples - DC series motor, simple passive networks with switches.

Simulation demonstration with different integration algorithms/step-sizes (Assignment/ Tutorial only).

Text Books

1. M. B. Patil, V. Ramanarayanan and V. T. Ranganathan, *Simulation of Power Electronic Circuits*, Narosa Publishing House.
2. Steven C. Chapra and Raymond P. Canale, *Numerical Methods for Engineers*, Tata McGraw Hill, 2000.
3. Rudra Pratap, *Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers*, Oxford University Press, 2010.
4. Rajkumar Bansal, Ashok Kumar Goel and Manoj Kumar Sharma, *MATLAB and its Applications in Engineering*, Pearson Education.

Reference Books

1. M. H. Rashid, *SPICE for Power Electronics and Electric Power*, Taylor and Francis Group.
2. Won Y. Yang, Wenwu Cao, Tae-Sang Chung and John Morris, *Applied Numerical Methods Using MATLAB*, John Wiley & Sons, 2005.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Formulation for Circuit Simulation	9
1.1	Types of simulation problems - DC simulation, transient simulation, AC simulation. Digital Circuit Simulation - sensitivity analysis , noise analysis. Examples.	2
1.2	Nodal Analysis - General Rules/Steps to form the admittance matrix. Sample problems on formulation of the matrix.	1
1.3	Modified Nodal Analysis (MNA) - General Rules/Steps to form the admittance matrix. Sample problems on formulation of the matrix. Formulation Examples.	1
1.4	Sparse Tableau Approach - Formulation of STA matrix. Features and comparison with MNA approach. Formulation Examples.	2
1.5	Non-linear Circuits: Application of the Newton-Raphson method - General procedure for n-th order system of equations, formulation of Jacobian. Examples. Resources required for simulation: Computation time, convergence issues - practical Limits due to finite precision. Damping.	3
	Module 2: Transient Simulation	10
2.1	Introduction to transient simulation- discretization of time, accuracy, stability, explicit and implicit schemes.	1
2.2	Review of backward Euler, forward Euler and trapezoidal methods	2
2.3	Basic ideas of Accuracy and Stability (Qualitative description only) of methods of transient analysis using numerical techniques.	2
2.4	Local Error (LE), Local Truncation Error (LTE) and Global Error. (No detailed derivations needed). Stiff systems - features, examples.	2
2.5	Equivalent circuit approach- RC circuit, Buck converter. Practical aspects in choosing numerical methods- undamped oscillations, ringing, global error in switching circuits, round-off error, assessment of accuracy, issue of singular matrix.	3
	Module 3: Introduction to SPICE	8
3.1	Types of simulation tools: Circuit simulation tools: SPICE, equation solvers: MATLAB®/Scilab®/Octave - Features, similarities and differences.	1

3.2	Circuit Simulation using SPICE, writing SPICE circuit files, SPICE Syntax - SPICE directives (Dot commands: .END, .FUNC, .NET .OPTIONS).	1
3.3	Performing different kinds of simulation and analysis - DC, DC sweep, AC, Transient and noise analyses. (Use of .OP, .PARAM, .TRAN, .DC, .STEP, .IC .MEASURE, .FOUR, .NOISE, .TEMP, .WAVE).	2
3.4	Developing circuit files for simple circuits like CE amplifiers, passive linear/non-linear circuits (Familiar Circuits with R, L, C, Diodes, Transistors).	2
3.5	Developing component models, subcircuits in SPICE. (Use of .MODEL, .SUBCKT, .LIB, .INC, .ENDS directives) - examples (BJTs/MOSFETs).	2
	Module 4: Introduction to Equation Solver Tools	9
4.1	Introduction to scripting using MATLAB®: Basic arithmetic operations, basic operators and special characters, variables and arrays.	2
4.2	Complex numbers -basic handling of arrays (Vectors and Matrices).	1
4.3	Control Structures (Conditional, looping - for loop, while loop, switch-case-otherwise - break -return) - functions.	2
4.4	Numerical Integration - ODE solvers - ode23, ode23t and ode45 – Examples.	2
4.5	User-written functions to solve ODEs to implement the algorithms BE, FE, and TRZ only). Application examples.	2
	Module 5: Visual Modelling	9
5.1	Visual Modelling: Introduction to Simulink/Similar Causal modelling tools.	1
5.2	Developing causal simulation diagrams using fundamental blocks (Gain, sum/difference, integrators, etc).	2
5.3	Simple circuit models- first-order/second-order circuits.	2
5.4	Separately excited DC Motor, from the ODE descriptions.	2
5.5	Non-linear examples: DC Series Motor, Simple passive networks with switches.	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Apply nodal analysis to form the admittance matrix for a given linear circuit.
2. Formulate the MNA equations for a circuit containing a voltage source and a current-controlled element.

3. Compare and analyze the equation structure obtained from Nodal Analysis and Sparse Tableau Approach for the same circuit.

Course Outcome 2 (CO 2)

1. Explain the difference between explicit and implicit numerical integration methods in transient simulation.
2. Apply Forward Euler, Backward Euler, or Trapezoidal Rule to compute the next time-step voltage of an RC circuit.
3. Identify practical issues such as stability or global error that may occur during transient simulation of switching circuits.

Course Outcome 3 (CO 3)

1. Analyze a SPICE netlist and identify errors in component naming, node numbering, or missing directives.
2. Interpret the output of a SPICE transient or DC sweep analysis and relate it to the expected circuit behavior.
3. Create a SPICE netlist for a CE amplifier or a simple nonlinear circuit including appropriate .MODEL and .TRAN directives.

Course Outcome 4 (CO 4)

1. Write a MATLAB script that uses ode45 to solve a first-order RL circuit ODE.
2. Implement a user-defined function in MATLAB to compute the derivative of a given differential equation.
3. Use MATLAB to compare the numerical solutions obtained using BE, FE, and TRZ methods for the same ODE.

Course Outcome 5 (CO 5)

1. Build a Simulink model of a first-order RC circuit using integrator and gain blocks.
2. Develop Simulink signal-flow diagrams for simulation of second order, first-order passive networks.
3. Create a Simulink diagram for a nonlinear system such as a DC series motor and analyze the output waveform.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: : B24EEH51

Course Name: : SIMULATION OF ELECTRIC SYSTEMS

Max. Marks: 100

Duration: 3 hours

PART A

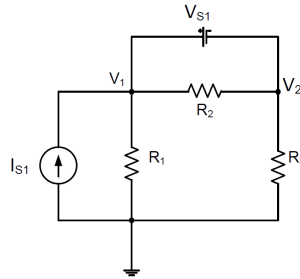
Answer all questions. Each question carries 3 marks.

1. Differentiate between DC simulation and Transient Simulation.
2. What is “convergence issue” in circuit simulation?
3. Differentiate between implicit and explicit numerical methods.
4. Define Local Truncation Error.
5. What is a “stiff system”? Give an example.
6. It is required to simulate a circuit with excessively oscillatory response. Out of Euler method and Trapezoidal method, which is suitable for this system, and why?
7. Differentiate between ‘.lib’ and ‘.inc’ SPICE directives.
8. Write the SPICE circuit file to run the transient simulation of an RC circuit excited by a pulse source of amplitude 5 V and frequency 1 kHz. The RC time constant is 0.1 ms (You may choose any R, C values that satisfy this requirement). Use end time of 1 s. Assume any missing information appropriately.
9. Write a MATLAB function to accept the coefficients of a quadratic polynomial and return the evaluated roots.
10. Develop the simulation signal-flow diagram for the simulation of a parallel RLC network excited by a current source, from the fundamental equations. Use standard blocks such as gain, sum/difference, integrators etc.

PART B

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

11. Form the Modified Nodal Analysis equations in matrix form for the given circuit.



OR

12. Explain about Newton Raphson method for solving nonlinear equation. Discuss with the help of example, where Newton Raphson method fails to converge.

13. (a) List various sources of error in numerical problems.

(4 marks)

- (b) Find approximate values of the solution at $t = 0.1, 0.2, 0.3, 0.4$ using Forward Euler with a step size of $h = 0.1$. $\frac{dy}{dt} = 2y - 1$, $y(0) = 1$. Show the numerically computed values at each step in a table.

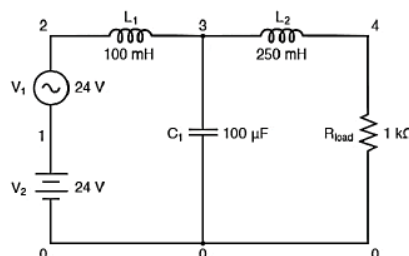
(10 marks)

OR

14. Compare the Backward Euler method, trapezoidal method and second order backward differentiation formula (BDF2-Gear's formula) methods.

(14 marks)

15. A SPICE circuit file of low-pass filter circuit is shown below. Write the SPICE script assuming initial conditions equal to zero. Write the code for AC source sweeping from 500 Hz to 15 kHz at ten points.



OR

16. A SPICE circuit file is shown below. Inspect the listing and draw the corresponding circuit diagram neatly. What kind of simulation is used here?

```
v1 1 0 dc 10
c1 1 2 47u ic=0
c2 1 2 22u ic=0
r1 2 0 3.3k
.tran .05 1 uic
.end
```

17. Consider an ODE of the form

$$x' = f(x, t) \quad \text{where} \quad f(x, t) = -6 \cos(2t) + 6 \sin(2t),$$

in the range $0 < t < 10$. The initial value is $x(0) = x_0 = 3$. Write a MATLAB script to solve the ODE for x using the Backward Euler method, without using dedicated ODE functions in MATLAB. Use a user-input value for the time step.

OR

18. List the Electrical equation, Electromechanical equations and Mechanical equation of separately excited DC motor with constant field excitation. Develop the simulation model of the individual equations.
19. Draw the simulation flow diagram to solve the following ordinary differential equation:

$$\ddot{y} + 9\dot{y} - 3y^3 - 1 = 18t$$

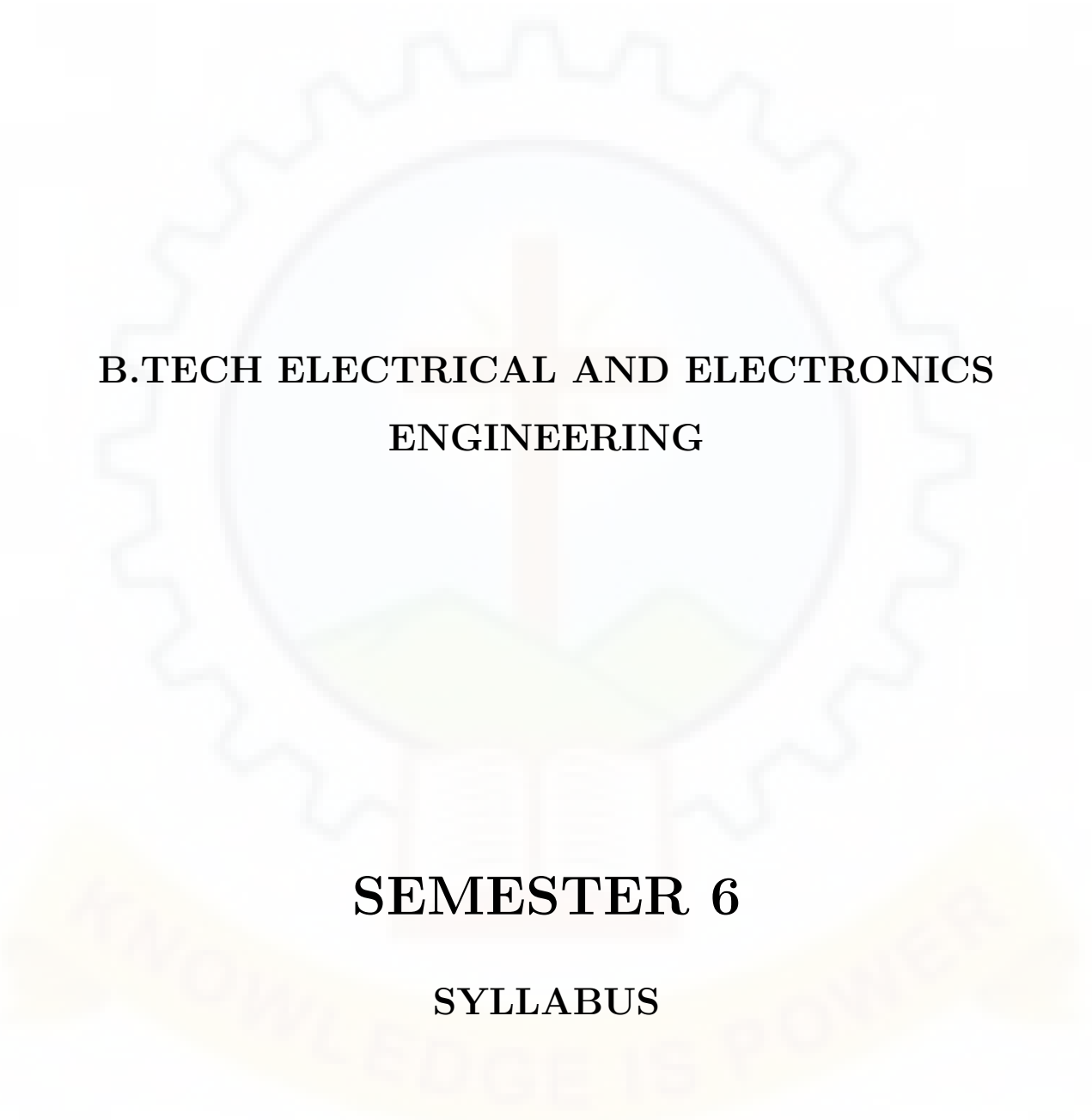
OR

20. Develop a simulation (signal-flow) diagram for a DC series motor fed from a dc voltage source and connected to a mechanical load. Take k_b as the back-emf constant and k_t as the torque constant of the motor, R_a the armature resistance, L_a the armature inductance, R_f , L_f are the field resistance and inductance respectively, J is the combined moment of inertia, and B is the viscous friction constant. The simulation diagram should show how the armature current i_a and the speed are derived. Show all the relevant equations from which the diagram is derived.

MAR ATHANASIOUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution

Kothamangalam, Kerala, India



**B.TECH ELECTRICAL AND ELECTRONICS
ENGINEERING**

SEMESTER 6

SYLLABUS

SEMESTER 6

SLOT	COURSE NO.	COURSES	L-T-P-S	HOURS	CREDIT
A	B24EE3T05	ADVANCED CONTROL SYSTEM	2-2-0-5	4	4
B	B24EE3T06	ELECTRIC DRIVES AND CONTROL	3-1-0-5	4	4
C	B24EE3T07	POWER SYSTEM II	2-2-0-5	4	4
D	B24EE3T08	OBJECT-ORIENTED PROGRAMMING	2-2-0-5	4	4
E	B24EE3P2X	PROGRAMME ELECTIVE II	2-1-0-4	3	3
F	B24EE3G1X	OPEN ELECTIVE I	2-1-0-4	3	3
G	B24EE3L09	ELECTRICAL MACHINES LAB II	0-0-3-2	3	2
H	B24EE3L10	CONTROL SYSTEMS LAB	0-0-3-2	3	2
M	B24EEM6X	MINOR	3-1-0-5	4	4
N	B24EEH6X	HONOURS	3-1-0-5	4	4
TOTAL				36	26

PROGRAMME ELECTIVE II

COURSE NO.	COURSES
B24EE3P21	INDUSTRIAL INSTRUMENTATION AND AUTOMATION
B24EE3P22	SWITCHED-MODE POWER CONVERTERS
B24EE3P23	ENERGY MANAGEMENT AND AUDITING
B24EE3P24	SYSTEM DESIGN USING HDL
B24EE3P25	COMMUNICATION SYSTEMS
B24EE3P26	DATA STRUCTURES AND ALGORITHMS

OPEN ELECTIVE I

COURSE NO.	COURSES
B24EE3G11	ELECTRICAL SAFETY
B24EE3G12	RENEWABLE POWER GENERATION SYSTEMS
B24EE3G13	ELECTRICAL POWER UTILIZATION
B24EE3G14	ENERGY MANAGEMENT AND AUDITING
B24EE3G15	INDUSTRIAL AUTOMATION
B24EE3G16	ELECTRIC VEHICLE TECHNOLOGY

MINOR

COURSE NO.	COURSES
BASKET 1	
B24EEM61	INDUSTRIAL INSTRUMENTATION AND AUTOMATION
BASKET 2	
B24EEM62	POWER ELECTRONIC DRIVES
BASKET 3	
B24EEM63	POWER SYSTEM AUTOMATION

HONOURS

COURSE NO.	COURSES
BASKET 1	
B24EEH61	ANALYSIS OF POWER ELECTRONIC CIRCUITS
BASKET 2	
B24EEH62	POWER SYSTEM DYNAMICS
BASKET 3	
B24EEH63	GENERALIZED MACHINE THEORY

B24EE3T05	ADVANCED CONTROL SYSTEM	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	2	0	5	4	2024

Preamble

The course aims to equip students with a strong foundation in state space analysis and non-linear system dynamics for modern control engineering applications. The content emphasizes modeling, analysis, stability assessment, and controller design for linear time-invariant and nonlinear systems using systematic state-space and Lyapunov-based approaches. By the end of the course, learners will gain the ability to analyze, model, and design controllers for real-world dynamic systems, ensuring stability and performance in various engineering applications.

Prerequisites

Linear Control System

Course Outcomes

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

CO 1	Apply the principles of state-space modelling to formulate and analyse state-space representations of linear time-invariant systems. (Cognitive knowledge level: Apply)
CO 2	Analyse system dynamics by solving state equations, and develop digital control system state space models. (Cognitive Knowledge Level: Apply)
CO 3	Design state feedback controllers and observers, based on controllability and observability criteria, and pole placement techniques. (Cognitive Knowledge Level: Apply)
CO 4	Analyse non-linear system behaviour through equilibrium point classification, phase-plane analysis, and limit cycle stability. (Cognitive knowledge level: Apply)
CO 5	Evaluate the stability of control systems using describing function techniques and Lyapunov stability theory. (Cognitive knowledge level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	2	2	2	1					1
CO 2	3	3	2	2	2	1					1
CO 3	3	3	2	2	2	1					1
CO 4	3	3	2	2	2	1					1
CO 5	3	3	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	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/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 (11 hours)

State Space Modelling

Introduction, concept of state, state variables and state space models, state space models for linear continuous time systems - electrical circuits and DC servomotors. Transfer function from state space model. Eigenvalues, eigenvectors, system stability. Similarity transformations and canonical forms - phase variable, controllable, diagonal, Jordan canonical forms.

MODULE 2 (10 hours)

State Space Analysis

Solution of state equations of LTI systems - state transition matrix, computation of state transition matrix using Laplace transform and Cayley Hamilton methods.

State space models for digital control systems - Phase variable form and diagonal canonical form from difference equation, pulse transfer function from state space model. Stability of linear digital control systems - Jury's test.

Use simulation software like MATLAB/Simulink to create state models. (Assignment/Tutorial only).

MODULE 3 (8 hours)

State Space-based Controller and Observer Design

Controllability and observability from state space models - Kalman test, Gilbert test, principle of duality, pole zero cancellation, design of state feedback controllers - dominant poles - pole placement technique, design of full order state observers.

Use simulation software like MATLAB/Simulink for state feedback controller design. (Assignment/ Tutorial only)

MODULE 4 (8 hours)

Analysis of Nonlinear Systems I

Nonlinear phenomena, different types of nonlinearities and their occurrence, equilibrium points, linearization, classification of equilibrium points, stability of equilibrium points. Phase plane analysis - Isocline method, limit cycles in phase plane, existence of limit cycle, stability of limit cycles.

MODULE 5 (8 hours)

Analysis of Nonlinear Systems II

Describing functions of common nonlinearities - relay, dead zone, and saturation, stability analysis by describing function method with single nonlinearity. Stability of non-linear systems - Lyapunov's first and second methods, variable gradient method for generation of Lyapunov function, Lyapunov method for linear systems.

Text Books

1. Katsuhiko Ogata, *Modern Control Engineering*, Pearson Prentice Hall, 5th ed., 2015.
2. I. J. Nagrath and M. Gopal, *Control Systems Engineering*, Tata McGraw-Hill, 7th ed., 2021.
3. M. Gopal, *Digital control and State Variable methods*, Tata McGraw-Hill, 4th ed., 2017.

Reference Books

1. K. P. Mohandas, *Modern Control Engineering*, Sanguine Pearson, Revised Edition, 2010.
2. Nise N. S., *Control Systems Engineering*, Wiley Eastern, 6th ed., 2018.
3. Hassan K Khalil, *Control Systems: An Introduction*, Michigan Publishing, 2023.
4. Benjamin C Kuo, *Digital Control Systems*, Oxford University Press, 2nd ed., 1995.
5. Hassan K Khalil, *Nonlinear Systems*, Prentice Hall International (UK), 3rd ed., 2002.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: State Space Modelling	11
1.1	Introduction, concept of state, state variables and state space models	1
1.2	State space models for linear continuous time systems - electrical circuits	2
1.3	State space models - DC servomotor	1
1.4	Transfer function from state space model	1
1.5	Eigenvalues, eigenvectors, system stability	1
1.6	Similarity transformations	1
1.7	Canonical form - phase variable form	1
1.8	Controllable canonical forms	1
1.9	Diagonal and Jordan canonical forms	2
	Module 2: State Space Analysis	10
2.1	Solution of state equations of LTI systems - autonomous system	1
2.2	Solution of state equations of LTI systems - forced system	2
2.3	Computation of state transition matrix using Laplace transform method	2
2.4	Computation of state transition matrix using Cayley Hamilton method	1
2.5	State space models for digital control systems - Phase variable form and diagonal canonical form from difference equation	2
2.6	Pulse transfer function from state space model	1
2.7	Stability of linear digital control systems - Jury's test	1
	Module 3: State Space-based Controller and Observer Design	8
3.1	Controllability - Kalman test, Gilbert test	1
3.2	Observability - Kalman test, Gilbert test	1
3.3	Principle of duality, pole zero cancellation	1
3.4	Design of state feedback controllers - pole placement technique	2
3.5	Design of state feedback controllers based on dominant poles	1
3.6	Design of full order state observers	2
	Module 4: Analysis of Nonlinear Systems I	8
4.1	Nonlinear phenomena, different types of nonlinearities and their occurrence	2
4.2	Equilibrium points, linearization	1

4.3	Classification of equilibrium points, stability of equilibrium points	2
4.4	Phase plane analysis - Isocline method	2
4.5	Limit cycles in phase plane, existence of limit cycle, stability of limit cycles	1
	Module 5: Analysis of Nonlinear Systems II	8
5.1	Describing functions analysis	1
5.2	Describing functions of common nonlinearities - relay, dead zone, and saturation	2
5.3	Stability analysis by describing function method with a single nonlinearity	2
5.4	Stability of nonlinear systems - Lyapunov's first and second methods	1
5.5	Variable gradient method for the generation of Lyapunov function	1
5.6	Lyapunov method for linear systems	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Develop the state-space models for linear continuous-time electrical circuits and DC servomotor.
2. Develop different canonical forms for a given LTI system.
3. Determine the stability of a linear time-invariant system.

Course Outcome 2 (CO 2)

1. Obtain the solution of the state equations of LTI systems.
2. Find the state transition matrix of a given LTI system.
3. Develop the state-space models for digital control systems in phase variable form and diagonal canonical form.

Course Outcome 3 (CO 3)

1. Check the controllability and observability for a given system.
2. Design of a state feedback controller.
3. Design of a full order state observer.

Course Outcome 4 (CO 4)

1. Explain the characteristics and types of nonlinearities.
2. Find all singular points of the system, classify them, and sketch the phase portrait in the neighbourhood of singular points.
3. Determine the equilibrium points and state the stability by constructing the phase trajectory using the method of isoclines.

Course Outcome 5 (CO 5)

1. Derive the describing function of relay, dead zone or saturation nonlinearity.
2. Determine the stability of nonlinear systems using describing function analysis.
3. Compute the Lyapunov function, for which the system given is asymptotically stable.

MODEL QUESTION PAPER

QP CODE:

Pages: 4

Reg.No.:

Name:

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),
KOTHAMANGALAM

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027

Course Code: : B24EE3T05

Course Name: : ADVANCED CONTROL SYSTEM

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What are phase variables? What are the advantages of choosing phase variables for state space modelling?
2. Develop the state-space model of a series RLC circuit excited by an input voltage $V(t)$, taking the inductor current and capacitor voltage as the state variables, and the capacitor voltage as the output.
3. Derive the solution of the state equation for an autonomous system.
4. Using the Cayley-Hamilton method, determine the state transition matrix for the system matrix $\mathbf{A} = \begin{bmatrix} 2 & 0 \\ 1 & 2 \end{bmatrix}$.
5. Illustrate the concept of duality referred to controllability and observability.
6. Explain Gilbert's method for testing the observability of a system with repeated eigenvalues.
7. Explain intentional and inherent nonlinearities with a suitable example.
8. Derive the describing function of relay nonlinearity.
9. Explain how stability is analysed by the second method (direct method) of Lyapunov.
10. Determine the definiteness of the function $V(x) = (x_1 + x_2)^2 + x_3^2$.

PART B

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

11. (a) Model the system described by the following differential equations in phase variable form.

$$\frac{d^3y}{dt^3} + 4\frac{d^2y}{dt^2} + 5\frac{dy}{dt} + 3y(t) = 5u(t)$$

(5 marks)

- (b) Derive the state-space model of an armature-controlled DC motor. Identify the state variables, input, and output, and briefly comment on the physical significance of each.

(9 marks)

OR

12. (a) Justify the statement “The state space representation of a system is not unique” with an appropriate example. (6 marks)

- (b) Consider the system given by

$$\frac{Y(s)}{U(s)} = \frac{3}{(s+1)(s+2)(s+3)}$$

Obtain the block diagram and construct the diagonal canonical form of the system.

(8 marks)

13. (a) A discrete-time system is described by the difference equation

$$y(k+3) + 2y(k+2) + 3y(k+1) + y(k) = 3u(k)$$

Find the state space representation of the system.

(5 marks)

- (b) Obtain the response $y(t)$ of the following system to a unit step input under $\begin{bmatrix} 1 \\ 0 \end{bmatrix}$ initial conditions.

$$\dot{\mathbf{x}} = \begin{bmatrix} -1 & 0 \\ 1 & -10 \end{bmatrix} \mathbf{x} + \begin{bmatrix} 0 \\ 10 \end{bmatrix} \mathbf{u}$$
$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} \mathbf{x}$$

(9 marks)

OR

14. (a) Obtain the state transition matrix $\phi(t)$ of the system described by

$$\dot{\mathbf{x}} = \begin{bmatrix} 0 & 0 & -2 \\ 0 & 1 & 0 \\ 1 & 0 & 3 \end{bmatrix} \mathbf{x}$$
$$y = \begin{bmatrix} 0 & 1 & 0 \end{bmatrix} \mathbf{x}$$

(7 marks)

- (b) Derive the phase variable form for the discrete-time system described by

$$\frac{Y(z)}{U(z)} = \frac{5}{z^3 + 7z^2 + 5z + 3}$$

(7 marks)

15. (a) Obtain the condition for complete state controllability for the electrical system described by the following state equations

$$\begin{bmatrix} \dot{V}_c \\ \dot{I}_L \end{bmatrix} = \begin{bmatrix} \frac{-2}{RC} & \frac{1}{C} \\ \frac{-1}{L} & 0 \end{bmatrix} \begin{bmatrix} V_c \\ I_L \end{bmatrix} + \begin{bmatrix} \frac{1}{RC} \\ \frac{1}{L} \end{bmatrix} V_s$$

(5 marks)

- (b) Consider a system described by the transfer function

$$\frac{Y(s)}{U(s)} = \frac{20(s+5)}{s(s+1)(s+4)}$$

Design a state feedback controller to yield a percentage overshoot of 9.5% and a settling time of 0.74 seconds. (9 marks)

OR

16. (a) What is a state observer? Under what conditions is an observer employed in the state feedback design of a control system? Briefly explain the configuration of an observer. (8 marks)
- (b) Consider the following state model of the system given by $\dot{x} = Ax + Bu$ and $y = Cx$ Where

$$\mathbf{A} = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix} \quad \mathbf{B} = \begin{bmatrix} 0 \\ 10 \end{bmatrix} \quad \mathbf{C} = [1 \quad 0]$$

Design a full-order observer such that observer poles are placed at $-1 \pm j$.

(6 marks)

17. (a) Explain any six nonlinear system behaviours. (6 marks)
- (b) Consider the nonlinear system described by the differential equation

$$\ddot{y} - 0.1\dot{y} + y + y^2 = 0$$

Find all singular points of the system. Classify them and sketch the phase portrait in the neighbourhood of the singularities.

(8 marks)

OR

18. (a) With a neat sketch, explain the isocline method for the construction of a phase trajectory.

(5 marks)

- (b) A linear second order system is described by the equation $\ddot{e} + 2\zeta\omega_n\dot{e} + \omega_n^2 e = 0$, Where $\zeta = 0.15$, $\omega_n = 1\text{rad/sec}$, $e(0)=1.5$, and $\dot{e}(0) = 0$. Determine the singular point and state the stability by constructing the phase trajectory using the method of isoclines.

(9 marks)

19. (a) Consider the nonlinear system described by the state equations

$$\dot{x}_1 = x_2$$

$$\dot{x}_2 = -x_1 - x_1^2 x_2$$

Check the stability of the equilibrium state of the system with $V(x) = x_1^2 + x_2^2$.

(5 marks)

- (b) Compute the Lyapunov function, $V(x)$, for which the system given below is asymptotically stable.

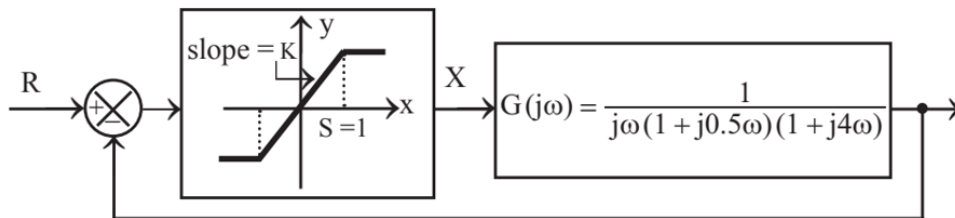
$$\dot{\mathbf{x}} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \mathbf{x}$$

(9 marks)

OR

20. Consider a unity feedback system having a saturating amplifier with gain K. Determine the maximum value of K for the system to stay stable. What would be the frequency and nature of the limit cycle for a gain of $K = 2.5$?

(14 marks)



B24EE3T06	ELECTRIC DRIVES AND CONTROL	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

The aim of this course is to provide a comprehensive understanding of electric drives and their control strategies for efficient operation in industrial and automation systems. The course covers fundamental concepts, dynamic behaviour, control techniques, and practical implementation of drives using DC motors, induction motors, synchronous motors and BLDC motors. Upon completion, students will be able to analyse motor performance and apply appropriate control methods to design and operate electric drive systems under various operating conditions.

Prerequisites

Electrical Machines I, Power Electronics, Electrical Machines II

Course Outcomes

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

CO 1	Understand the fundamental principles of electric drives and apply the concepts to analyse the dynamic performance. (Cognitive Knowledge Level: Apply)
CO 2	Understand and apply the various closed-loop control techniques used in conventional electric drive systems. (Cognitive knowledge Level: Apply)
CO 3	Analyse the performance of DC motor drives under various operating modes. (Cognitive knowledge Level: Apply)
CO 4	Apply the speed control techniques for induction motor drives used in high-performance drive applications. (Cognitive knowledge Level: Apply)
CO 5	Explain the principles and analyse performance of synchronous and BLDC motor drives used in high-performance applications. (Cognitive knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	1	1							1
CO 2	3	2	2	2							1
CO 3	3	2	2	2	1				1		2
CO 4	3	2	2	2							2
CO 5	3	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	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 (8 hours)

Dynamics of Electric Drives

Introduction to electric drives - needs, merits, block diagram, key components. Motor-load system dynamics - equivalent motor-load system, fundamental torque equations, multi-quadrant operation of drives, equivalent values of drive parameters, load torques - components, classifications, time and energy loss in transient operation, steady state stability, numerical problems.

MODULE 2 (8 hours)

Control of Electric Drives

Modes of operation, principle of speed control, speed transition paths, drive classifications. Closed-loop control of drives - current-limit control, torque control, speed control, single and multi-motor drives, speed sensing, current sensing, phase-locked-loop control, position control - block diagram.

MODULE 3 (11 hours)

DC Motor Drives

Speed control of DC motor drives - armature voltage control, field flux control, armature resistance control.

Controlled rectifier-fed DC drives - schematic representation, single-phase fully-controlled and half-controlled rectifier-fed DC separately excited motor - discontinuous and continuous conduction modes, three-phase fully controlled and half-controlled rectifier-fed DC separately excited motor - continuous conduction mode, numerical problems.

Chopper-controlled DC drives - chopper control of separately excited DC motor, motoring control, regenerative braking, dynamic braking, numerical problems.

MODULE 4 (9 hours)

Induction Motor Drives

Speed control of three-phase induction motors - pole changing, stator voltage control, stator frequency control, v/f control - Voltage Source Inverter (VSI) control, eddy current drives, rotor resistance control, slip power recovery control, numerical problems.

Space vector control - concept, Clarke and Park transformations, field orientation principle.

MODULE 5 (9 hours)

Synchronous and BLDC Motor Drives

Variable frequency control of synchronous motor, operating modes - true synchronous mode and self-controlled mode, variable frequency control of multiple synchronous motors. Load commutated inverter-based synchronous motor drive - closed-loop speed control, block diagram.

Brushless DC motor drives - principle of operation of BLDC motor, BLDC motor drive for servo applications.

Use simulation software like MATLAB/Simulink for simulation of electric drives (Assignment / Tutorial only)

Text Books

1. G. K. Dubey, *Fundamentals of Electric Drives*, Narosa publishers, 2nd ed., 2022.
2. Bimal K Bose, *Modern Power Electronics and AC Drives*, Pearson Education India, 1st ed., 2015.
3. R Krishnan, *Electric Motor Drives: Modeling, Analysis, and Control*, Pearson Education India, 1st ed., 2015.
4. A. Veltman, D. W. J. Pulle, and R. W. D. Doncker, *Fundamentals of Electrical Drives*, Springer-Verlag New York Inc., 2nd ed., 2007.

Reference Books

1. V. Subrahmanyam, *Electric Drives Concepts and Applications*, McGraw-Hill Education, 2nd ed., 2011.
2. Dr. P. S. Bimbhra, *Power Electronics*, Khanna publishers, 5th ed., 2012.
3. N. K. De, and P. K. Sen, *Electric Drives*, Prentice Hall India Learning Pvt. Ltd., 1st ed., 2002.
4. Ned Mohan, *First Course on Power Electronics and Drives*, John Wiley & Sons Inc., 1st ed., 2011.
5. Dewan S.B., G. R. Slemon, and A. Strauven, *Power semiconductor drives*, Wiley India Pvt Ltd., 1st ed., 2009.
6. S. K. Pillai, *A First Course on Electrical Drives*, New Age International Pvt. Ltd., 4th ed., 2022.
7. Austin Hughes and Bill Drury, *Electric Motors and Drives Fundamentals, Types and Applications*, Newnes, 5th ed., 2019.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Dynamics of Electric Drives	8
1.1	Introduction to electric drives - needs, merits, block diagram, key components	1
1.2	Motor-load system dynamics - equivalent motor-load system	1
1.3	Fundamental torque equations	1
1.4	Multi-quadrant operation of drives	1
1.5	Equivalent values of drive parameters	1
1.6	Load torques - components, classifications	1
1.7	Time and energy loss in transient operation, steady state stability	1
1.8	Numerical problems - electric drives	1
	Module 2: Control of Electric Drives	8
2.1	Modes of operation of electric drives	1
2.2	Principle of speed control, speed transition paths, drive classifications	1
2.3	Closed-loop control of drives - current-limit control	1
2.4	Torque control, speed control,	1
2.5	Single and multi-motor drives	1
2.6	Speed sensing, current sensing	1
2.7	Phase-locked-loop control	1
2.8	Position control - block diagram	1
	Module 3: DC Motor Drives	11
3.1	Speed control of DC motor drives - armature voltage control	1
3.2	Field flux control, armature resistance control	1
3.3	Controlled rectifier fed DC drives - schematic representation	1
3.4	Single-phase fully-controlled rectifier-fed DC separately excited motor - discontinuous and continuous conduction modes	1
3.5	Single-phase half-controlled rectifier-fed DC separately excited motor - discontinuous and continuous conduction modes	1
3.6	Three-phase fully-controlled rectifier-fed DC separately excited motor - continuous conduction mode	1
3.7	Three-phase half-controlled rectifier-fed DC separately excited motor - continuous conduction mode	1
3.8	Numerical Problems - controlled rectifier fed DC drives	1

3.9	Chopper-controlled DC drives - chopper control of separately excited DC motor	1
3.10	Motoring control, regenerative braking, dynamic braking	1
3.11	Numerical Problems - chopper-controlled DC drives	1
	Module 4: Induction Motor Drives	9
4.1	Speed control of three-phase induction motors - pole changing	1
4.2	Stator voltage control, stator frequency control, v/f control	2
4.3	Voltage source inverter (VSI) control, eddy current drives	1
4.4	Rotor resistance control, slip power recovery control	1
4.5	Numerical problems - induction motor drives	1
4.6	Space Vector Control - concept	1
4.7	Clarke and Park transformations, field orientation principle	2
	Module 5: Synchronous and BLDC Motor Drives	9
5.1	Variable frequency control of synchronous motor	1
5.2	Operating modes - true synchronous mode and self-controlled mode	1
5.3	Variable frequency control of multiple synchronous motors	2
5.4	Load commutated inverter-based synchronous motor drive	1
5.5	Closed-loop speed control, block diagram	1
5.6	Brushless DC motor drives – principle of operation of BLDC motor	2
5.7	BLDC motor drive for servo applications	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the block diagram of an electric drive system.
2. Differentiate between passive and active load torques.
3. Problems on electric drives.

Course Outcome 2 (CO 2)

1. Explain the constant torque region and constant power region in the speed control of an electric drive.
2. Draw and explain the block schematic diagram of a closed loop speed control of an electric drive.
3. Explain the armature voltage control and field weakening mode control of DC separately excited motor drive system.

Course Outcome 3 (CO 3)

1. Describe the primary methods used to control the speed of a DC motor in a drive system.
2. State and explain how armature current and speed of a DC separately excited motor will be affected by halving the armature voltage and field current with load torque remaining constant.
3. Problems on DC motor drives.

Course Outcome 4 (CO 4)

1. Describe the speed-torque characteristics of a variable stator voltage controlled induction motor.
2. Explain the principle of field oriented control of a three phase induction motor.
3. Problems on induction motor drives.

Course Outcome 5 (CO 5)

1. Illustrate the power and torque capability curves of a synchronous motor drive.
2. Explain the v/f control characteristics in torque-speed plane of a SM drive.
3. Problems on synchronous motor drives.

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: : B24EE3T06

Course Name: : ELECTRIC DRIVES AND CONTROL

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Draw and explain the speed-torque curve of a traction load.
2. Explain the function of each block in the block diagram of an electric drive.
3. How is speed sensing performed in electric drives?
4. For a separately excited DC motor, how is operation above its rated base speed achieved?
5. Explain the principle of regenerative braking in a DC motor drive.
6. Justify why the armature current of a DC motor must be limited during starting or sudden load changes in a drive system.
7. Why square wave inverter fed induction motor drives are not popular?
8. Justify why v/f ratio is maintained constant up to base speed, in an induction motor drive system.
9. When a synchronous motor is operating in true synchronous mode, frequency must be varied in steps, Why?
10. Explain the operation of a BLDC motor drive.

PART B

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

11. (a) What are the different components of a load torque? Explain each component in detail.

(7 Marks)

- (b) Derive the mathematical condition to obtain the steady state stability of equilibrium point.

(7 Marks)

OR

12. With the help of neat diagram, explain the multi-quadrant operation of an electric drive.

(14 Marks)

13. Explain the different closed-loop control techniques applied in electric drives.

(14 Marks)

OR

14. With neat diagram, describe the operation of multi-motor electric drive systems.

(14 Marks)

15. Explain the armature voltage control and field flux control based speed regulation of separately excited DC motor drives. Also, draw and explain the torque and power capability curves.

(14 Marks)

OR

16. A 220 V, 1500 rpm, 50 A separately excited motor with armature resistance of 0.6Ω is fed from a three-phase fully controlled rectifier. Available AC source has a line voltage of 440 V, 50 Hz. A star-delta connected transformer is used to feed the armature so that motor terminal voltage equals rated voltage when the converter firing angle is zero. Determine the value of firing angle when: (i) motor is running at 1200 rpm and rated torque, (ii) motor is running at 800 rpm and twice the rated torque, and (iii) motor is running at 1000 rpm and half the rated torque.

(14 Marks)

17. With neat schematic diagram, explain the slip power recovery technique applied in three-phase induction motor drives.

(14 Marks)

OR

18. (a) Explain the frame transformation from three-phase to synchronous reference frame. What is its significance in induction motor drive?

(7 Marks)

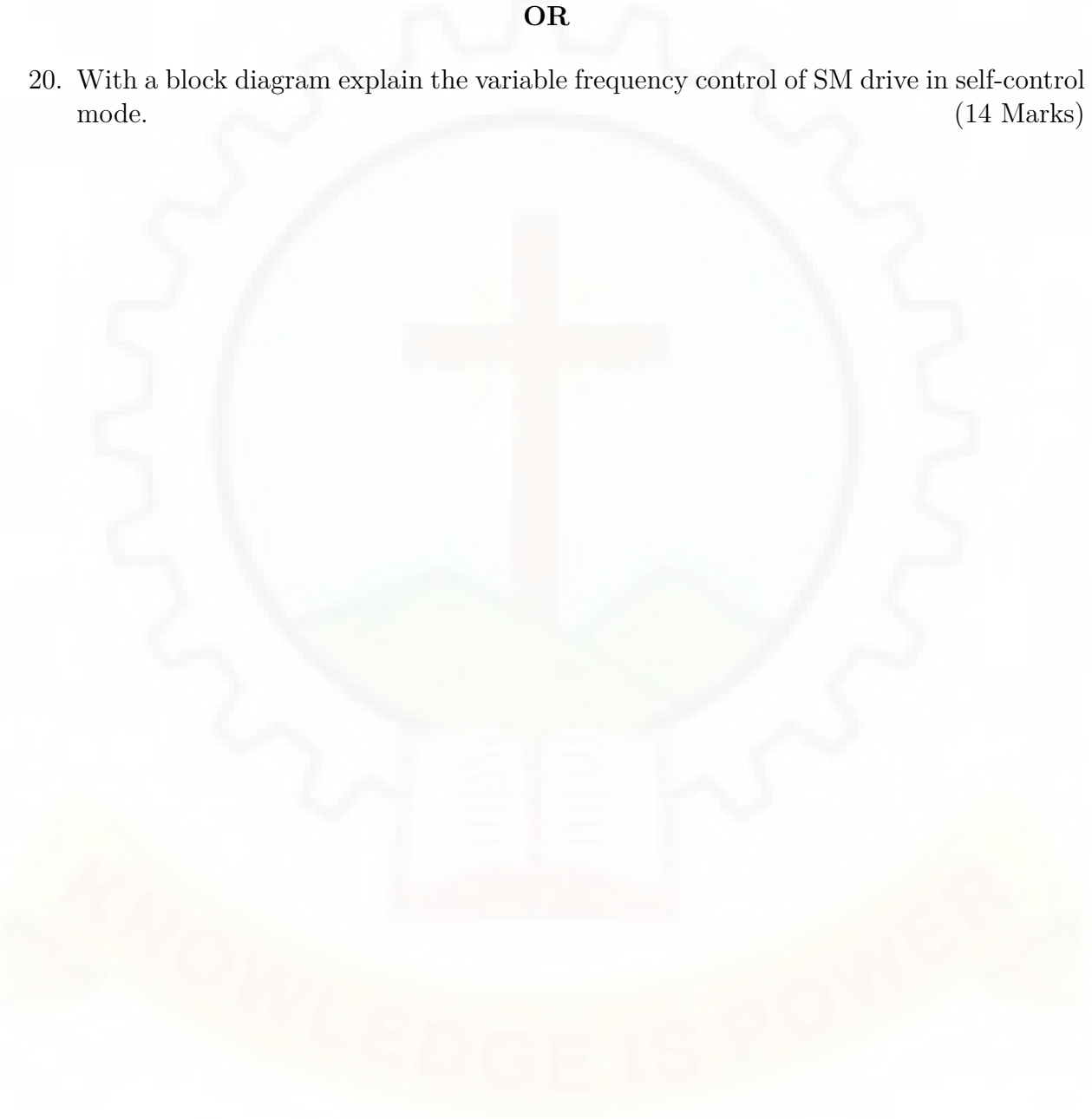
- (b) Describe the operational features of VSI fed induction motor drive.

(7 Marks)

19. A 3 MW, three-phase 11 kV, star connected, 6 pole, 60 Hz, 0.9 leading power factor synchronous motor has $X_s = 9 \Omega$ and $R_s = 0.1 \Omega$. Rated field current is 45 A. Machine is controlled by variable frequency control at constant V/f ratio up to the base speed and at constant voltage, above the rated speed. Determine (i) Torque and field current for the rated armature current, 750 rpm and 0.8 leading power factor (ii) Armature current and power factor for half the rated motor torque, 1500 rpm and rated field current. (14 Marks)

OR

20. With a block diagram explain the variable frequency control of SM drive in self-control mode. (14 Marks)



B24EE3T07	POWER SYSTEM II	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	2	0	5	4	2024

Preamble

The basic objective of this course is to deliver fundamental concepts in power system analysis. This course provides a comprehensive understanding of power system operation and control, covering load flow studies, fault analysis, stability, automatic generation control, and economic operation. By the end of the course, students will be able to analyze and apply control and optimization techniques to evaluate power system operations.

Prerequisites

Power System I

Course Outcomes

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

CO 1	Understand the representation of power system components and apply load flow analysis techniques to formulate network models and analyze power system performance under steady-state conditions. (Cognitive Knowledge Level: Apply)
CO 2	Apply symmetrical components, and sequence networks to analyze symmetrical and unsymmetrical faults in power systems. (Cognitive Knowledge Level: Apply)
CO 3	Apply appropriate methods to determine and analyze various stability issues in power systems under steady state, dynamic, and transient conditions. (Cognitive Knowledge Level: Apply)
CO 4	Apply automatic generation and voltage control strategies to achieve stable operation of interconnected power networks. (Cognitive Knowledge Level: Apply)
CO 5	Understand economic dispatch and unit commitment techniques for optimal generation scheduling, considering transmission losses and system constraints. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	1	2	1	2					1
CO 2	3	3	1	2	3	2					1
CO 3	3	3	1	2	1	2					1
CO 4	3	3	1	2	3	2					1
CO 5	3	2	1	1	1	3				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/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)

Representation of Power System Components

Per unit quantities - single phase and three phase, single line diagram, reactance diagram.

Load Flow Studies

Introduction, network model formulation and admittance matrix, load flow problem, Gauss-Seidel (two iterations), Newton-Raphson - qualitative analysis, fast decoupled method (two iterations), principle of DC load flow.

MODULE 2 (9 hours)

Fault Analysis

Symmetrical components, sequence impedance, sequence networks, fault calculations - symmetrical and unsymmetrical - LG, LL, LLG, fault analysis using Z-Bus, fault level of installations, current limiting reactors.

Use simulation software like MATLAB/Scilab to perform fault analysis (Assignment/ tutorials only).

MODULE 3 (10 hours)

Stability Analysis

Power system stability - steady state, dynamic and transient stability, power angle curve, steady state stability limit, mechanics of angular motion-swing equation, solution of swing equation - point by point method and Runge-Kutta method, equal area criterion - application, methods of improving stability limits, IEEE/IEC standards for stability and grid interconnection.

MODULE 4 (9 hours)

Automatic Generation and Voltage Control

Load frequency control-single area- turbine speed governing system, turbine model, generator load model, block diagram, numerical problems, two area systems, automatic voltage control - exciter control, block diagram, SCADA systems, Phasor Measurement Units (PMU), wide area monitoring systems.

Use simulation software like MATLAB/Scilab to simulate single-area and two-area systems (Assignment/tutorials only)

MODULE 5 (8 hours)

Economic Dispatch and Generation Scheduling

Economic operation - distribution of load between units within a plant, transmission loss as a function of plant generation, distribution of load between plants, method of computing penalty factors and loss coefficients.

Unit commitment - introduction, constraints on unit commitments - spinning reserve, thermal unit constraints, hydro constraints, dynamic scheduling.

Text Books

1. Hadi Saadat, *Power System Analysis*, Tata McGraw Hill, 2nd ed., 2002.
2. D. P. Kothari, I. J. Nagrath and R K Saket, *Modern Power System Analysis*, Tata McGraw Hill, 5th ed., 2022.
3. Kundur P., *Power system Stability and Control*, McGraw Hill, 2nd ed., 2022.

Reference Books

1. John J. Grainger and William D. Stevenson, *Power System Analysis*, McGraw Hill, 4th ed., 1994.
2. Cotton H. and H. Barbera, *Transmission & Distribution of Electrical Energy*, Hodderand Stoughton, 3rd ed., 1994.
3. Gupta B. R., *Power System Analysis and Design*, S. Chand & Company, 2nd ed., 2008.
4. Gupta J. B., *Transmission & Distribution of Electrical Power*, S.K. Kataria & Sons, 10th ed., 2021.
5. Soni, M. L., P. V. Gupta and U. S. Bhatnagar, *A Course in Electrical Power*, Dhanpat Rai & Sons, 2022.
6. Uppal S. L. and S. Rao, *Electrical Power Systems*, Khanna Publishers, 15th ed., 2009.
7. Wadhwa C. L., *Electrical Power Systems*, New Age International, 33th ed., 2004.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1:Representation of Power System Components	9
1.1	Per unit quantities - single phase and three phase - numerical problems	1
1.2	Reactance diagram - numerical problems	1
	Load Flow Studies	
1.3	Load flow studies - introduction, types	1
1.4	Network model formulation and admittance matrix - numerical problems	2
1.5	Load flow problem, Gauss-Seidel (two iterations) - numerical problems	1
1.6	Newton-Raphson - qualitative analysis	1
1.7	Fast decoupled method (two iterations) - numerical problems	1
1.8	Principle of DC load flow	1
	Module 2: Fault Analysis	9
2.1	Symmetrical components	1
2.2	Sequence networks - numerical problems	2
2.3	Fault calculations - symmetrical - numerical problems	1
2.4	Unsymmetrical Fault Analysis- LG - numerical problems	1
2.5	Unsymmetrical Fault Analysis- LL, LLG - numerical problems	2
2.6	fault analysis using Z-Bus	1
2.7	Fault level of installations, current limiting reactors - numerical problems	1
	Module 3: Stability Analysis	10
3.1	Power system stability - steady state, dynamic and transient stability	1
3.2	Power angle curve, steady state stability limit - numerical problems	2
3.3	Mechanics of angular motion - swing equation	1
3.4	Solution of swing equation - point by point method	1
3.5	Solution of swing equation - Runge-Kutta method	1
3.6	Equal area criterion - application	2
3.7	Equal area criterion - numerical problems	1
3.8	Methods of improving stability limits, IEEE/IEC standards for stability and grid interconnection	1
	Module 4: Automatic Generation and Voltage Control	9

4.1	Load frequency control-single area- turbine speed governing system	1
4.2	Turbine model, generator load model - numerical problems	2
4.3	Block diagram representation of load frequency control of isolated power system - steady state analysis - numerical problems	2
4.4	Two area load frequency control	1
4.5	Automatic voltage control - exciter control, block diagram	1
4.6	SCADA systems, Phasor Measurement Units (PMU), wide area monitoring systems - abstract idea only	2
	Module 5: Economic Dispatch and Generation Scheduling	8
5.1	Economic operation - distribution of load between units within a plant, transmission loss as a function of plant generation - numerical problems	2
5.2	Economic operation - distribution of load between plants - numerical problems	2
5.3	Method of computing penalty factors and loss coefficients - numerical problems	2
5.4	Unit commitment - introduction, constraints on unit commitments - spinning reserve, thermal unit constraints, hydro constraints	1
5.5	Dynamic scheduling	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Problems related to per-unit system in power system analysis.
2. Problems related to Gauss-Seidel method of load flow analysis.
3. Application of the Newton-Raphson method for Load flow analysis.
4. Problems related to Fast decoupled load flow analysis.

Course Outcome 2 (CO 2)

1. Derivations of sequence impedance and sequence networks.
2. Problems related to symmetrical and unsymmetrical faults in power system.
3. Problems related to fault analysis using Z-Bus.

Course Outcome 3 (CO 3)

1. Explain various terms associated with power system stability.
2. Derivation and problems related to application of equal area criterion and critical clearing angle under various fault conditions.
3. Analysis of power system stability under various fault conditions.

Course Outcome 4 (CO 4)

1. Derivation of transfer function of various components of LFC.
2. Problems on change in frequency of a single area system subjected to sudden load changes.
3. Analysis of two- area control systems.

Course Outcome 5 (CO 5)

1. Explain unit commitment and constraints in unit commitment.
2. Problems on economic dispatch considering transmission losses.
3. Derivation of conditions of economic load dispatch.

MODEL QUESTION PAPER

QP CODE:

Pages: 4

Reg.No.:

Name:

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

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027

Course Code: : B24EE3T07

Course Name: : POWER SYSTEM II

Max. Marks: 100

Duration: 3 hours

PART A

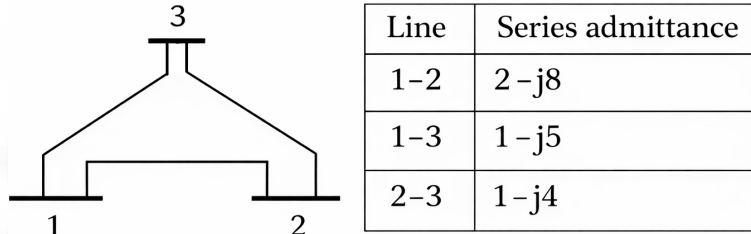
Answer all questions. Each question carries 3 marks.

1. A single phase transformer is rated at 110/440 V, 2.5 kVA. Leakage reactance measured from LT side of the transformer is 0.06Ω . Determine the leakage reactance in p.u.
2. Classify the various types of buses in a power system for load flow studies.
3. Draw the zero sequence networks of a) Y-Y b) Y- Δ connected transformers.
4. Explain current limiting reactors.
5. What is critical clearing angle? Obtain expressions for the same.
6. Write all methods to improve steady state stability limit of power system.
7. Why should the system frequency be maintained constant?
8. Obtain the block diagram representation of generator-load model.
9. Explain unit commitment and constraints in unit commitment.
10. Derive the condition for economic dispatch when losses are considered.

PART B

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

11. (a) The figure below shows a 3 bus power system. The line and bus data are given in p.u. Neglect line charging admittance. Form Y_{BUS} and compute voltages at the end of the first Gauss-Seidel iteration.



Bus	P	Q	V	Remarks
1	-	-	$1.04 \angle 0^\circ$	Slack bus
2	-0.2	-0.2	-	PQ
3	-0.1	-0.3	-	PQ

(10 marks)

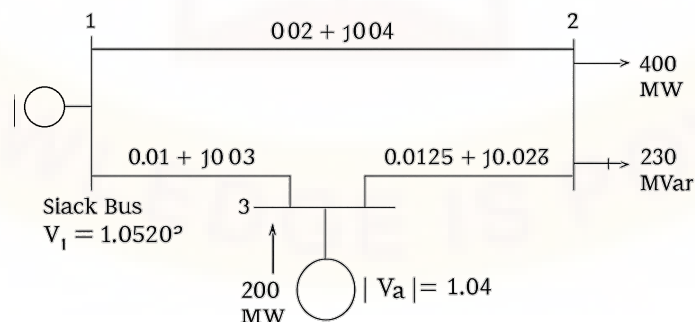
- (b) What is Jacobian matrix? What are the advantages and disadvantages of Newton-Raphson method?

(4 marks)

OR

12. (a) For the system shown, obtain the power flow solution by Fast Decoupled Load flow. The voltage at bus 1 is adjusted to 1.05 p.u. Voltage magnitude at bus 3 is fixed at 1.04 p.u. with real power generation of 200MW. A load consisting of 400MW and 250MVAR is taken from bus 2. Line impedances are marked in per unit on a 100MVA base and line susceptances are neglected.

(10 marks)



- (b) An incomplete nodal admittance matrix for a 4 bus system is given. Find the missing terms.

$$\begin{bmatrix} 0.7 - j3 & -0.2 + j1 & -0.5 + j2 & y_{14} \\ y_{21} & y_{22} & -0.3 + j2 & -0.5 + j3 \\ y_{31} & y_{32} & y_{33} & -1 + j4 \\ y_{41} & y_{42} & y_{43} & y_{44} \end{bmatrix}$$

(4 marks)

13. (a) Derive the expression for fault current and draw the interconnection of sequence networks for a double line to ground fault on the terminals of an unloaded generator.

(10 marks)

- (b) A 50 MVA, 11 kV, three-phase synchronous generator was subjected to different types of faults. The fault currents are as follows: LG fault: 4130 A, LL fault: 2590 A three-Phase fault: 1870 A. The generator neutral is solidly grounded. Find the p.u values of sequence reactances of the generator. (4 marks)

OR

14. (a) A synchronous generator and a synchronous motor are rated 25 MVA, 11 kV and having sub transient reactance of 15 % are connected through transformers and a transmission line. The transformers are rated 25 MVA, 11/66 kV and 66/11 kV respectively with leakage reactance of 10 %. The line connecting them has a reactance of 10 % on the base of 25 MVA, 66 kV. The motor is drawing 15 MW at 0.8 pf lead and a terminal voltage of 10.6 kV when a symmetrical 3 phase fault occurs at the motor terminals. Find the sub transient current in the motor, generator and fault.

(10 marks)

- (b) What are symmetrical components? Obtain the symmetrical components of the following set of unbalanced currents. $I_a = 10\angle 60^\circ$, $I_b = 10\angle -60^\circ$, $I_c = 0$.

(4 marks)

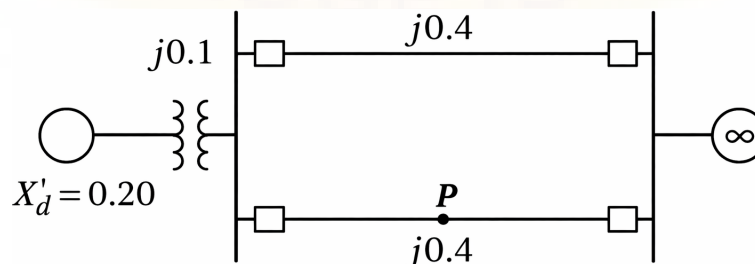
15. (a) Using equal area criterion, derive an expression for critical clearing angle for a system having a generator feeding an infinite bus through a single circuit line.

(10 marks)

- (b) Explain the point by point method for the solution of swing equation. (4 marks)

OR

16. (a) The single-line diagram of the figure shows a power system, where power is fed through parallel transmission lines to a large metropolitan system considered as an infinite bus. The machine is delivering 1.0 per unit power and both the terminal voltage and infinite-bus voltage are both 1.0 per unit. The reactances of all components are shown on the diagram. a) Determine the power angle equation for the given system. b) If a three-phase fault occurs at point P, find the new power angle equation. Plot the two curves. (10 marks)



- (b) Draw a diagram to illustrate the application of equal area criterion to study transient stability when there is a sudden increase in the input of generator. (4 marks)

17. (a) Draw the block diagram representation of Load Frequency Control (LFC) of a single area system and explain the steady state stability for free governor operation. (10 marks)

- (b) A 125 MVA turbo-alternator on full load operates at 50 Hz. A load of 50 MW is suddenly reduced on the machine. The steam valves to the turbine commence to close after 0.5 s due to the time lag in the governor system. Assuming the inertia to be constant, $H = 6$ kWs per kVA of generator capacity, calculate the change in frequency that occurs in this time. (4 marks)

OR

18. (a) Draw the schematic diagram voltage regulator of a turbo-generator and explain. (4 marks)

- (b) With neat diagram explain turbine speed governing system. Also derive the block diagram model of turbine speed governing system for steam turbine. (10 marks)

19. (a) The cost curves of two plants of a generating system are, $\frac{dF_1}{dP_1} = 0.012P_1 + 6.6$ and $\frac{dF_2}{dP_2} = 0.00962P_1 + 6$. The loss coefficient for the above system is given as $B_{11} = 5 \times 10^{-3}$, $B_{12} = B_{21} = -0.03 \times 10^{-3}$, $B_{22} = 8 \times 10^{-3}$ on a base of 100 MVA. If plant 1 supplies 200 MW and plant 2 supplies 300 MW, find the penalty factors of each plant. Is the present dispatch economical? If not, which plant output must be increased and which one decreased? Give reasons for the same. (10 marks)

- (b) What do you mean by spinning reserve? Why the spinning reserve must be maintained. (4 marks)

OR

20. (a) What are B-coefficients? Write the expression for transmission loss in terms of B-coefficients when there are three generating stations.? (4 marks)

- (b) A power plant has 3 units with the following cost curves:

$$C_1 = P_1^2 + 430P_1 + 10000 \text{ Rs/hr}$$

$$C_2 = 2P_2^2 + 540P_2 + 10000 \text{ Rs/hr}$$

$$C_3 = 1.4P_3^2 + 320P_3 + 18000 \text{ Rs/hr}.$$

Maximum and minimum generation for each unit is 120 MW and 36 MW. Find the optimum scheduling for a total load of 200 MW. (10 marks)

B24EE3T08	OBJECT ORIENTED PROGRAMMING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	2	0	5		

Preamble

The aim of the course is to equip the students to develop solutions for real world problems using Object oriented Concepts in Python. This course introduces the terminology of the object-oriented paradigm and focuses on object-oriented design using Python with step-by-step examples. After the completion of the course, students will be able to design and implement Python applications for real world problems.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand and implement Python programming language constructs - basic and collection data types, string manipulations, decision making statements and looping constructs. (Cognitive Knowledge Level: Understand)
CO 2	Implement Functions in Python, build modules and packages and file operations in Python. (Cognitive Knowledge Level: Apply)
CO 3	Understand object-oriented programming concepts and implement in Python. (Cognitive Knowledge Level: Understand)
CO 4	Develop Python programs using object-oriented programming constructs and perform exception handling. (Cognitive Knowledge Level: Apply)
CO 5	Interpret problems using python libraries – Numpy, Pandas, SciPy and Matplotlib. (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	2	2	2	2	2	1	1		1	2
CO 2	3	2	2	2	2	2	1	1	1	1	2
CO 3	3	2	3	2	2	2	1	1		1	2
CO 4	3	2	2	2	2	2	1	1	1	1	2
CO 5	3	2	2	2	2	2	1	1	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/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)

Introduction to Python

Variables and expressions, operators, input statements, data types, accessing and manipulation of tuples, lists, sets, dictionaries and strings.

Decision-Making Statements and Loops

Decision-making - if statement, if-else statement, if-elif-else statement, nested-if statements. Looping constructs - for loop, for loop with else, while loop, while loop with else statement and nested loops, break, continue, pass statements. Example programs.

MODULE 2 (10 hours)

Functions

Definition, types of arguments, recursive functions, anonymous functions (lambda functions), string manipulations, simple programs using functions.

Modules and Packages

Creating modules, import statements, built-in packages, creating user-defined packages.

File Handling

Opening a file, closing a file, writing to a file, reading from a file, directories in Python. Example programs.

MODULE 3 (9 hours)

Object-Oriented Concepts in Python

Advantages of object-oriented programming, class definition, creating objects, built-in attribute methods, built-in class attributes. Encapsulation, data hiding, inheritance, deriving a child class, program for single inheritance, multiple inheritance, method overriding, example programs.

MODULE 4 (9 hours)

Polymorphism

Operator overloading-example programs, Python programs using classes and objects.

Exception Handling

Built-in exceptions, handling exceptions, Exception with arguments, raising an exception, user-defined exceptions, assertions in Python, example programs.

MODULE 5 (8 hours)

NumPy Arrays

NumPy library, ndarray, basic operations (indexing, slicing, shape/reshape, join, split, search, sort, filter), reading and writing array data to files.

Pandas

Series, data frames and analysing data.

SciPy

Introduction to sub-packages – integrate, optimise and stats.

Matplotlib

Creating line plots, bar plots, scatter plots and histograms.

Text Books

1. Charles Dierbach, *Introduction to Computer Science using Python*, Wiley, 3rd ed., 2019.
2. Kenneth A Lambert., *Fundamentals of Python: First programs*, Cengage Publishing, 2nd ed., 2016.
3. Downey, A. et al., *How to think like a Computer Scientist: Learning with Python*, John Wiley, 3rd ed., 2020.
4. Dr. Charles R Severance, *Python for everybody: Exploring data using Python 3*, Shroff Publishers, 2017.
5. Jeeva Jose, *Taming Python by Programming*, Khanna Publishers, 2018.

Reference Books/Online Sources

1. Wesley J. Chun, *Core Python Applications Programming*, Pearson Education, 3rd ed., 2016.
2. Zed A Shaw, *Learn Python 3 The Hard Way*, Addison-Wesley, 2017.
3. Numpy – official website <https://numpy.org>.
4. Pandas – official website <https://pandas.pydata.org>.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Introduction to Python	9
1.1	Variables and expressions, operators	1
1.2	Input statements, data types	1
1.3	Data types	1
1.4	Accessing and manipulation of tuples, list	1
1.5	Sets, dictionaries and strings	1
	Decision-Making Statements and Loops	
1.6	Decision-making - if statement, if-else statement, if-elif-else statement	1
1.7	Nested-if statements. Looping constructs - for loop	1
1.8	for loop with else, while loop, while loop with else statement and nested loops	1
1.9	break, continue, pass statements. Example programs	1
	Module 2: Functions	10
2.1	Definition, types of arguments	1
2.2	Recursive functions	1
2.3	Anonymous functions (lambda functions)	1
2.4	String manipulations	1
2.5	Simple programs using functions	1
	Modules and Packages	
2.6	Creating modules, import statements	1
2.7	Built-in packages, creating user-defined packages	1
	File Handling	
2.8	Opening a file, closing a file	1
2.9	Writing to a file, reading from a file	1
2.10	Directories in Python. Example programs	1
	Module 3: Object-Oriented Concepts in Python	9
3.1	Advantages of object-oriented programming, class definition	1
3.2	Creating objects, built-in attribute methods	1
3.3	Built-in class attributes	1
3.4	Encapsulation, data hiding	1
3.5	Inheritance, deriving a child class	1
3.6	Program for single inheritance	1
3.7	Program for multiple inheritance	1
3.8	Method overriding	1
3.9	Example programs	1
	Module 4: Polymorphism	9
4.1	Polymorphism	1
4.2	Operator overloading	1

4.3	Example programs	1
4.4	Python programs using classes and objects	1
	Exception Handling	
4.5	Exception handling	1
4.6	Built-in exceptions, handling exceptions	1
4.7	Exception with arguments, raising an exception	1
4.8	User-defined exceptions	1
4.9	Assertions in Python, example programs	1
	Module 5: NumPy Arrays	8
5.1	NumPy Arrays, NumPy library, ndarray, basic operations indexing, slicing	1
5.2	Shape/reshape, join, split, search, sort, filter	1
5.3	Reading and writing array data to files	1
	Pandas, SciPy and Matplotlib	
5.4	Pandas: Series, data frames and analysing data	1
5.5	SciPy: Introduction to sub-packages – integrate, optimise and stats	1
5.6	Matplotlib: Creating line plots	1
5.7	Bar plots, scatter plots and histograms	1
5.8	Example programs	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain datatypes available in Python.
2. Analyze various types of operators in Python.
3. Differentiate break and continue statements.

Course Outcome 2 (CO 2)

1. Explain the function definition and function calling in python.
2. Illustrate with an example the working of recursive functions.
3. Write a program to copy a text file to another file.

Course Outcome 3 (CO 3)

1. What are the advantages of Object Oriented Programming?
2. Write a Python class to convert an integer to a roman numeral.
3. Explain single inheritance with an example.

Course Outcome 4 (CO 4)

1. Briefly explain exception handling in Python.
2. What are assertions in Python?
3. Explain exception with arguments.

Course Outcome 5 (CO 5)

1. How are Numpy arrays different from Python Lists?
2. Create a simple Pandas series from a list.
3. Create a simple plot using Matplotlib.

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: : B24EE3T08

Course Name: : OBJECT ORIENTED PROGRAMMING

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What are the datatypes available in Python?
2. Explain the concept of tuple in Python.
3. Write a Python function to reverse a string. Import the module to reverse a string input by the user.
4. Write a program to copy a text file to another file.
5. What are the advantages of Object Oriented Programming?
6. Illustrate single inheritance with an example.
7. What are assertions in Python?
8. Interpret Operator Overloading in Python.
9. List out the key features and uses of Numpy.
10. Differentiate Numpy and SciPy.

PART B

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

11. Write a Python program to generate prime numbers between two limits. (14 marks)

OR

12. Explain various decision making statements in Python with examples. (14 marks)

13. (a) Explain Lambda functions. (4 marks)

- (b) Elaborate the function definition and function calling in Python with an example. (10 marks)

OR

14. Illustrate the various modes for opening a file using example programs. (14 marks)

15. Explain the concept of class and objects in Python. (14 marks)

OR

16. Explain method overriding with an example. (14 marks)

17. Briefly explain the Object Oriented Concepts in Python with examples. (14 marks)

OR

18. Illustrate exception with arguments. (14 marks)

19. What is Pandas? Create a simple Pandas Data Frame. (14 marks)

OR

20. What is Matplotlib? Create a simple plot using Matplotlib. (14 marks)

B24EE3L09	ELECTRICAL MACHINES LAB-II	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

The aim of this course is to make the students gain practical knowledge about the various types of Synchronous and Induction machines by understanding and analysing their characteristics under different working conditions, thereby enabling them to cater the requirements of the Power and Electrical machines Industry confidently, upholding the ethical principles and sustainable standards.

Prerequisite

Electrical Machines II

Course Outcomes

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

CO 1	Understand and apply analysis on the voltage regulation in alternators and its causes. (Cognitive level: Apply)
CO 2	Understand and analyse the performance characteristics of alternators. (Cognitive Knowledge Level: Analyse)
CO 3	Identify and analyse the performance on load, speed and torque control for different classifications of induction motors. (Cognitive Knowledge Level: Analyse)
CO 4	Develop and analyse the equivalent circuit and circle diagrams for different induction motors and to understand and analyse the performance of an induction generator connected to grid. (Cognitive level: Analyse)
CO 5	Develop the team management skills and prepare laboratory reports that logically and scientifically communicate experimental information. (Cognitive level : Apply)

Mapping of Course Outcomes with Program Outcomes

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

Mark Distribution

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

Continuous Internal Evaluation Pattern

Attendance	10 marks
Continuous Assessment	15 marks
Performance	10 marks
Viva-Voce	5 marks
Lab Record	5 marks
Internal Exam	20 marks

End Semester Examination (ESE) Pattern:

The following guidelines should be followed regarding the award of marks

1. Preliminary work: 25 marks
 - (a) Circuit Diagram: 15 marks
 - (b) Theory and Procedure: 10 marks
2. Implementing the work/Conducting the experiment: 30 marks (usage of equipment and troubleshooting)
3. Result and Inference: 15 marks
4. Viva Voce: 30 marks

Students having a certified Lab Record are only eligible to appear for the End Semester Examination.

SYLLABUS

LIST OF EXPERIMENTS

1	Voltage Regulation of a three-phase cylindrical rotor type alternator using a) Direct loading b) EMF and MMF method c) Potier method
2	Blondel's/slip test on a three-phase salient pole alternator.
3	Reactive power control in grid connected alternators (V curves).
4	Power - angle characteristics of salient/non salient synchronous alternator.
5	V and inverted V curves of a synchronous motor.
6	a) Load test on a three-phase squirrel cage induction motor by starting it with Y- Δ starter. b) V/f speed control of three-phase squirrel cage induction motor.
7	Load test on a three-phase slip ring induction motor.
8	a) Load Test on a single-phase induction motor. b) No load and block rotor tests on a single-phase induction motor.
9	Variation of starting torque with rotor resistance in slip ring induction motor.
10	No load and block rotor tests on a three-phase squirrel cage induction motor.
11	Performance characteristics of a three-phase induction generator.
12	Speed control of three-phase induction motor using cascading method.

Reference Books

1. J. B. Gupta., *Theory and Performance of Electrical Machines*, S. K. Kataria and Sons, 2015.
2. Bimbra P. S., *Electric Machines*, Khanna Publishers, 2nd ed., 2017.
3. Kothari D. P., Nagrath I. J., *Electric Machines* , Tata McGraw Hill, 5th ed., 2017.
4. Say M. G., *The Performance and Design of AC Machines*, CBS Publishers, 3rd ed., 2002.
5. Alexander S. Langsdorf, *Theory of Alternating Current Machinery*, Tata McGraw Hill, 2nd revised ed., 2001.

B24EE3L10	CONTROL SYSTEMS LAB	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

This course aims to provide practical insight into the modeling, analysis, and design of control systems using experimental setups and software tools like MATLAB and SIMULINK. The experiments cover transfer function determination, compensator design, performance analysis, and controller implementation for various electromechanical systems. By the end of the course, students will gain the ability to analyze, design, and verify control strategies for real-time engineering applications.

Prerequisite

Linear Control System

Course Outcomes

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

CO 1	Develop transfer functions experimentally for electrical machines and control systems such as DC motors, generators, and servo motors. (Cognitive Knowledge Level: Apply)
CO 2	Analyze system performance using time-domain and frequency-domain methods, including root locus, step response, and frequency response techniques. (Cognitive Knowledge Level: Apply)
CO 3	Design and implement compensators and controllers for achieving desired performance specifications using simulation software like MATLAB/Simulink and through industrial controllers such as PLCs using ladder programming. (Cognitive Knowledge Level: Apply)
CO 4	Apply modern computational tools to develop state-space models, system responses, and controller designs for simulation-based and practical analysis. (Cognitive Knowledge Level: Apply)
CO 5	Develop the team management skills and prepare laboratory reports that logically and scientifically communicate experimental information. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Mark Distribution

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

Continuous Internal Evaluation Pattern

Attendance	10 marks
Continuous Assessment	15 marks
Performance	10 marks
Viva-Voce	5 marks
Lab Record	5 marks
Internal Exam	15 marks
Micro project	5 marks

End Semester Examination (ESE) Pattern:

The following guidelines should be followed regarding the award of marks

1. Preliminary work: 25 marks
 - (a) Circuit diagram/Program: 15 marks
 - (b) Theory/Design and Procedure: 10 marks
2. Implementing the work/Conducting the experiment: 30 marks (usage of equipment and troubleshooting)
3. Result and Inference: 15 marks
4. Viva Voce: 30 marks

Micro Project: Students must complete a mandatory micro project in groups of up to four members. The project should involve designing/modelling/experimentally validating a simple control system to analyse its dynamic behaviour and performance. This project will be evaluated as part of the continuous internal evaluation, with a maximum of 5 marks. **Students having a certified Lab Record and Micro Project Report are only eligible to appear for the End Semester Examination.**

SYLLABUS

LIST OF EXPERIMENTS

1	Determine the transfer function of the given armature controlled and field-controlled DC Motor by experiment.armature-controlled.
2	Design lead and lag compensators, and obtain the characteristics by experiment and simulation.
3	Determine the transfer function of a separately excited DC Generator by experiment.
4	Determine the transfer function of AC servo motor by experiment.
5	Obtain the different performance characteristics of synchro transmitter-receiver.
6	Obtain the step response of a second-order system and determine the time domain parameters using simulation.
7	Analysis the stability using the root-locus and Bode plot methods using simulation.
8	Design of lag and lead compensators for frequency domain specifications using MATLAB.
9	Design of lag and lead compensators for time domain specifications using MATLAB.
10	Design and analysis of a PID controller for a given system using SIMULINK/MATLAB.
11	Determine the open loop stability, controllability and observability and design a state feedback controller by pole-placement technique using MATLAB for a given system.
12	Develop a PLC based speed control system for a DC motor.

Reference Books

1. Katsuhiko Ogata, *Modern Control Engineering*, Pearson Prentice Hall, 5th ed., 2015.
2. I. J. Nagrath and M. Gopal, *Control Systems Engineering*, Tata McGraw Hill, 7th ed., 2021.
3. K. P. Mohandas, *Modern Control Engineering*, Sanguine Pearson, Revised Edition, 2010





PROGRAMME ELECTIVE II

B24EE3P21	INDUSTRIAL INSTRUMENTA- TION AND AUTOMATION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4		

Preamble

This course aims to provide a comprehensive understanding of the foundational principles and modern applications of automatic process control systems. This course deals in detail with classic control fundamentals, modern instrumentation like virtual instruments, PLCs, DCS, SCADA and their integration for automating substations, manufacturing and process industries. Upon completion, students will be equipped with the knowledge and skills necessary to design and implement complex industrial automation systems.

Prerequisites

Electrical Measurements, Instrumentation Systems

Course Outcomes

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

CO 1	Explain the basics of Automatic process control and virtual instrumentation systems. (Cognitive knowledge level: Understand)
CO 2	Develop the logic for the process control applications using PLC programming. (Cognitive knowledge level: Apply)
CO 3	Explain the evolution and architectures of DCS, analyze LCU structure and languages, and evaluate process interfacing, communication, and security issues in DCS design and implementation. (Cognitive knowledge level: Understand)
CO 4	Describe the concepts of SCADA Communication systems. (Cognitive knowledge level: Understand)
CO 5	Apply substation and distribution automation principles to design and implement automated solutions for reliable, efficient, and resilient grid operations. (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	2	2	1	3	2	1				2
CO 2	3	2	3	1	3	2	1				2
CO 3	2	2	2	1	2	2	1				2
CO 4	2	2	2	1	2	2	1				2
CO 5	2	2	3	1	2	2	1				2

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	20	40	20
Understand	40	60	40
Apply	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 (7 hours)

Fundamentals of Automatic Process Control

Automatic process control - process definition, open loop control, closed loop control, PID control, controller operation, control system response, controllability of process, control loop tuning, multi-variable control, control loop robustness, feedforward control.

Transducers and Actuators

Transducers - definition, nature, intelligent sensors, biosensors, nano sensors, fibre interferometric sensor. Final control element - pneumatic actuation, hydraulic actuation, electric actuation, motor actuators, control valves, MEMS valves.

Virtual Instrumentation System

Architecture of virtual instruments, virtual instruments and traditional instruments, concepts of graphical programming.

MODULE 2 (9 hours)

Programmable Logic Controllers (PLC)

Shift registers in PLC - ladder programs, data handling, arithmetic functions, closed loop control, program development, safe systems, PLC installation - operating environment, receiving check, testing and assembly, electrical connecting, grounding and suppression, circuit protection and wiring, fault finding, trouble shooting and maintenance of PLC, commissioning of PLC system. Design, development and simulation of PLC program on temperature control, valve sequencing, conveyor belt control, control of a process.

MODULE 3 (8 hours)

Distributed Control System

Evolution, various architectures, comparison, Local Control Unit (LCU) - functional blocks, comparison of architectures, LCU languages-language requirements, function blocks, high-level languages. Process interfacing issues - LCU interfaces to distributed system elements, security design issues, process input/output design issues, communication facilities - system requirements, architectural issues, protocol issues, communication system standards.

MODULE 4 (6 hours)

SCADA Communication

Building blocks of SCADA system, introduction, communication requirements, smart grid communication infrastructure, communication topologies and techniques, data communication, communication protocol architecture, SCADA and smart grid protocols.

MODULE 5 (6 hours)

Substation and Distribution Automation

Substation automation - need, smart devices, levels of automation, technical issues, new digital substation, substation automation architectures, comparison, application functions. Distribution automation - Introduction, subsystems in a distribution control centre, Distribution Management System (DMS) framework, DMS application functions, advanced real-time DMS, applications.

Text Books

1. William Bolton, *Programmable Logic Controllers*, Elsevier India Pvt Ltd, 6th ed., 2015.
2. John W Webb and Ronald A Reis, *Programmable Logic Controllers - Principles and Applications*, Prentice Hall India Learning Private Limited, 5th ed., 2002.
3. Michael P. Lucas, *Distributed Control system*, Van Nostrand Reinhold Company, 1986.
4. Mini S Thomas and John D Mc Donald, *Power System SCADA and Smart Grids*, CRC Press, Taylor and Francis Group, 1st ed., 2015.
5. Krishna Kant, *Computer Based Industrial Control*, PHI Learning Pvt Ltd, 2nd ed., 2010.

Reference Books

1. DVS. Murty, *Transducers and Instrumentation*, PHI Learning Pvt Ltd, 2nd ed., 2013.
2. A.K. Sawhney, *A Course in Electrical Measurements, Electronic Measurements and Instrumentation*, Dhanpat Rai and Co., 2015.
3. G.K.McMillan, *Process/Industrial Instrument and control and hand book*, McGraw Hill, 5th ed., 1999.
4. Patranabis, D, *Principles of Industrial Instrumentation*, Tata McGraw Hill Publishing Co. Ltd., 3rd ed., 2010.

5. Robert B. Northrop, *Introduction to instrumentation and measurements*, CRC, Taylor and Francis, 3rd ed., 2018.
6. Curtis D Johnson, *Process Control Instrumentation Technology*, Pearson New International Edition, 8th ed., 2005.
7. Doebelin E.O, *Measurement Systems: Application and Design*, McGraw Hill, 5th ed., 2004.
8. Stuart A. Boyer, *SCADA: Supervisory Control and Data Acquisition*, International Society of Automation, 4th ed., 2010.
9. Sunit Kumar Sen, *Fieldbus and Networking in Process Automation*, CRC Press, 1st ed., 2014.
10. Jovitha Jerome, *Virtual instrumentation using LabVIEW*, PHI Learning Pvt Ltd, 2010.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Fundamentals of Automatic Process Control	7
1.1	Process definition, open loop control, closed loop control, PID control	1
1.2	Controller operation, control system response, controllability of process, control loop tuning	1
1.3	Multi-variable control, control loop robustness, feedforward control	1
1.4	Transducers – definition and nature, intelligent sensors, biosensors, nano sensors, fibre interferometric sensor. (types and working principle)	1
1.5	Final control element - pneumatic actuation, hydraulic actuation, electric actuation	1
1.6	Motor actuators, control valves, MEMS valves	1
1.7	Architecture of virtual instruments, virtual instruments and traditional instruments, concepts of graphical programming (basics only)	1
	Module 2: Programmable Logic Controllers (PLC)	9
2.1	Shift registers in PLC - ladder programs	1
2.2	Data handling	1
2.3	Arithmetic functions, closed loop control	1
2.4	Program development	1

2.5	Safe systems, PLC installation – operating environment, receiving check, testing and assembly, electrical connecting, grounding and suppression	1
2.6	Circuit protection and wiring, fault finding, trouble shooting and maintenance of PLC, commissioning of PLC system	2
2.7	Design, development and simulation of PLC program on temperature control, valve sequencing	1
2.8	Design, development and simulation of PLC program on conveyor belt control, control of a process	1
	Module 3: Distributed Control System	8
3.1	Evolution, various architectures, comparison	1
3.2	Local Control Unit (LCU) - functional blocks, comparison of architectures	1
3.3	LCU languages-language requirements, function blocks	1
3.4	High-level languages	1
3.5	Process interfacing issues - LCU interfaces to distributed system elements, security design issues	1
3.6	Process input/output design issues	1
3.7	Communication facilities - system requirements, architectural issues	1
3.8	Protocol issues, communication system standards	1
	Module 4: SCADA Communication	6
4.1	Building blocks of SCADA system, introduction, communication requirements, smart grid communication infrastructure	1
4.2	Communication topologies and techniques	1
4.3	Data communication	1
4.4	SCADA communication protocol architecture	1
4.5	SCADA and smart grid protocols	2
	Module 5: Substation Automation and Distribution Automation	6
5.1	Substation automation - need, smart devices	1
5.2	Levels of automation, technical issues, new digital substation	1
5.3	Substation automation architectures, comparison, application functions	1
5.4	Introduction, subsystems in a distribution control	1
5.5	Distribution Management System (DMS) framework	1
5.6	DMS application functions- advanced real-time DMS applications	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Analyse behaviour of a different feedback control actions using P, PI, PID controllers.
2. Explain working principle of piezoelectric biosensor.
3. Illustrate architecture of virtual instruments.

Course Outcome 2 (CO 2)

1. Ladder programs to achieve sequence/tracking by the use of shift register.
2. Describe various steps involved in commissioning of PLC.
3. Design a PLC program for temperature control in a domestic central heating system.

Course Outcome 3 (CO 3)

1. Illustrate generalised distributed control system architecture.
2. Explain basic elements of a Local Control Unit.
3. Describe the language requirements for control-oriented language selected for DCS.

Course Outcome 4 (CO 4)

1. Describe and contrast various SCADA communication topologies.
2. Explain various modes of digital data communication.
3. Illustrate and explain OSI seven-layer model with its functionalities

Course Outcome 5 (CO 5)

1. Explain new smart devices for substation automation.
2. Illustrate and explain various levels of substation automation.
3. Explain Outage management systems (OMS) in distribution automation.

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: : B24EE3P21

Course Name: : INDUSTRIAL INSTRUMENTATION AND AUTOMATION

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. List out the advantages of PID control.
2. Explain the construction and working of a nano pressure sensor.
3. List out the various steps for commissioning PLC.
4. Explain the significance of Emergency stop relays.
5. Illustrate the hybrid system architecture of DCS.
6. Explain the basic elements of a Local Control Unit.
7. What are the various SCADA data communication techniques?
8. Differentiate between Synchronous and Asynchronous data transmission.
9. Why Substation automation is gaining momentum throughout the world?
10. What are the various levels of automation in a substation?

PART B

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

11. Illustrate the configuration of a generalised biosensor and explain various types of biosensors used in the field of process control. Also list out its various applications.
(14 marks)

OR

12. Explain the architecture of a virtual instrumentation system. Compare traditional instruments and virtual instruments.
(14 marks)
13. Design a PLC ladder logic program that is used to count the number of items put onto a conveyor belt from work cells and give an alert when the number reaches 100.
(14 marks)

OR

14. Design a PLC ladder logic program to operate Car park barrier using pneumatic valves.
(14 marks)
15. With neat diagram explain each components of generalised distributed control system architecture. Also give a comparison between hybrid, central computer and distributed architecture.
(14 marks)

OR

16. (a) Illustrate LCU interfaces to distributed system elements.
(7 marks)
- (b) What are the various security design approaches for the Local Control Unit.
(7 marks)
17. With the help of a neat diagram explain the functionalities of a seven-layer OSI model.
(14 marks)

OR

18. Explain about the following SCADA protocols with necessary diagrams, a) Modbus b) IEC 60870-5-101/103/104 c) Distributed network protocol 3 (DNP3).
(14 marks)
19. (a) What are the various technical issues to be faced while automating substation.
(7 marks)
- (b) Describe the three architectural levels of new digital substation with neat diagram.
(7 marks)

OR

20. Explain the subsystems in a distribution control centre with necessary diagrams.
(14 marks)

B24EE3P22	SWITCHED-MODE POWER CONVERTERS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces the basic working and types of switched mode converters used for efficient power conversion. Students will learn about different converter circuits, control methods, flyback converters, and how to design magnetic components like inductors and transformers. By the end of the course, they will be able to analyze, model, and design simple power converter systems for practical use.

Prerequisites

Power Electronics

Course Outcomes

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

CO 1	Explain and compare linear and switched-mode power supplies, and analyze, design non-isolated DC–DC converters operating in CCM and DCM. (Cognitive Knowledge Level: Analyze)
CO 2	Analyze and model second-order switched mode power converters, and design voltage mode control systems using small-signal techniques and compensators. (Cognitive Knowledge Level: Analyze)
CO 3	Explain and analyze isolated DC–DC converter topologies and apply design equations to select suitable converter configurations for various power electronic applications. (Cognitive Knowledge Level: Apply)
CO 4	Select suitable magnetic devices used in power electronic converters and design filter inductors and transformers for given converter specifications. (Cognitive Knowledge Level: Apply)
CO 5	Design practical switched-mode power converters by selecting appropriate components, develop suitable control transfer functions and compensators. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	3	3	1		1			2	3
CO 2	3	3	3	3	1		1			2	3
CO 3	3	3	3	3			1			2	3
CO 4	3	3	3	3	1		1		1	2	3
CO 5	3	3	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	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 (8 hours)

Switched Mode Power Supplies

Linear voltage regulators - basic operating principle, types, key characteristics, limitations. Introduction to Switched Mode Power Supplies (SMPS) - basic principle, general SMPS architecture, comparison with linear regulators, advantages of SMPS, applications of SMPS.

Non-Isolated DC-DC Converters

Buck, boost and buck-boost switching regulators - basic circuit diagram, principle of operation and waveforms. CCM and DCM operation, derivation of duty ratio, design of filter inductance and capacitance, boundary between continuous and discontinuous conduction - critical values of inductance/load resistance, design examples.

MODULE 2 (8 hours)

Control of SMPC and PWM Techniques

Modelling and control of second-order switched-mode power converters: State space averaging and linearization, small signal approximation and circuit averaged model, voltage mode control - transfer functions, stability, design of compensators. PWM control techniques - unipolar and bipolar switching, current mode control - hysteresis control.

MODULE 3 (7 hours)

Isolated DC-DC Converters

Need for galvanic isolation in power converters, comparison between isolated and non-isolated topologies, forward converter topology-basic operation, waveforms, practical forward converter, design examples, push-pull converter-flux walking, half and full bridge converters - basic operation and waveforms.

Flyback converters - circuit schematic, principle of operation, discontinuous mode of operation, continuous conduction mode - design equations, disadvantages of flyback converters, applications of flyback converters.

MODULE 4 (7 hours)

Transformer Design and Challenges in Isolated Converters

Types of magnetic devices - filter inductor, AC inductor, transformer, coupled inductor, flyback transformer, magnetic design - design constraints of filter inductor and transformer, step-by-step design procedures, design example of filter inductor and transformer, thermal

considerations.

MODULE 5 (6 hours)

Design of Practical Converters

250 W off-line forward converter - selection of input capacitors, transformer turns ratio, output inductor selection, output capacitor selection, control transfer function, compensator design, 500 W current-controlled push-pull converter - transformer turns ratio, transformer VA rating, output inductor selection, output capacitor selection.

Text Books

1. Ned Mohan, Tore M. Undeland, William P. Robbins, *Power Electronics: Converters, Applications, and Design*, John Wiley & Sons, 6th ed., 2021.
2. Robert W. Erickson and Dragan Maksimovic, *Fundamentals of Power Electronics*, Springer Nature, 3rd ed., 2020.
3. Daniel W. Hart, *Power Electronics*, McGraw-Hill Education, 1st ed., 2010.
4. Abraham Pressman, Keith Billings, and Taylor Morey, *Switching Power Supply Design*, McGraw-Hill, 3rd ed., 2009.
5. L. Umanand, *Power Electronics: Essentials and Applications*, Wiley India Pvt. Ltd., 1st ed., 2009.

Reference Books

1. V. Ramanarayanan, *Switched Mode Power Conversion*, Course text/academic textbook material, Indian Institute of Science, Bangalore, 2007.
2. M. H. Rashid, *Power Electronics: Circuits, Devices and Applications*, PHI/Pearson, 4th ed., 2017.
3. Philip T. Krein, *Elements of Power Electronics*, Oxford University Press, 1st ed., 1998.
4. Texas Instruments Incorporated, *Application Notes and Reference Designs in Power Electronics*, URL: <https://www.ti.com>.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Switched Mode Power Supplies	8
1.1	Introduction, Linear Voltage Regulators- Basic Operating Principle, Types, Key Characteristics, Limitations.	1
1.2	Introduction to Switched Mode Power Supplies (SMPS)- - basic principle, general SMPS architecture.	1
1.3	Comparison with linear regulators, advantages of SMPS, applications of SMPS.	1
	Non-Isolated DC-DC Converters	
1.4	Buck switching regulators - CCM and DCM operation - derivation of duty ratio.	1
1.5	Design equations and examples.	1
1.6	Boost switching regulators - CCM and DCM operation - derivation of duty ratio.	1
1.7	Design equations and examples.	1
1.8	Buck Boost switching regulators - CCM and DCM operation - derivation of duty ratio, Design equations	1
	Module 2: Control of SMPC and PWM Techniques	9
2.1	Modelling and control of second-order switched-mode power converters.	1
2.2	State space averaging and linearization.	2
2.3	Small signal approximation and circuit averaged model.	2
2.4	Voltage mode control - transfer functions.	1
2.5	Stability, design of compensators.	1
2.6	PWM control techniques - unipolar and bipolar switching.	1
2.7	Current mode control - hysteresis control.	1
	Module 3: Isolated DC-DC Converters	7
3.1	Need for galvanic isolation in power converters, comparison between isolated and non-isolated topologies.	1
3.2	Forward converter topology-basic operation, waveforms, practical forward converter, design examples	1
3.3	Push-pull converter-flux walking	1
3.4	Half and full bridge converters - basic operation and waveforms.	1
3.5	Flyback converters - circuit schematic, principle of operation, discontinuous mode of operation.	1
3.6	Continuous conduction mode - design equations	1
3.7	Disadvantages of flyback converters, applications of flyback converters.	1
	Module 4: Transformer Design and Challenges in Isolated Converters	7

4.1	Types of magnetic devices - filter inductor, AC inductor, transformer, coupled inductor, flyback transformer.	2
4.2	Magnetic design - design constraints of filter inductor and transformer	2
4.3	Step-by-step design procedures	1
4.4	Design example of filter inductor and transformer, thermal considerations	2
	Module 5: Design of Practical Converters	6
5.1	250 W off-line forward converter.	1
5.2	Selection of input capacitors, transformer turns ratio, output inductor selection, output capacitor selection.	1
5.3	Control transfer function, compensator design.	1
5.4	500 W current-controlled push-pull converter.	1
5.5	Transformer turns ratio, transformer VA rating.	1
5.6	Output inductor selection, output capacitor selection.	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the basic operating principle of a linear voltage regulator.
2. Draw and explain the general block diagram of an SMPS.
3. Explain the working principle of a buck converter with circuit diagram and waveforms. Derive the output voltage–duty ratio relationship for CCM operation.

Course Outcome 2 (CO 2)

1. Define state-space averaging and explain its significance in modelling switched-mode power converters.
2. What is meant by linearization of a nonlinear SMPC model? Why is it required for control design?
3. Define small-signal approximation in SMPS control.

Course Outcome 3 (CO 3)

1. What is galvanic isolation in power converters? Why is it required?
2. Define flux walking in push–pull converters.

3. Explain the basic operation of a forward converter with neat circuit diagram and waveforms.

Course Outcome 4 (CO 4)

1. List the different types of magnetic devices used in isolated power converters.
2. Define a flyback transformer and state how it differs from a conventional transformer.
3. Describe the step-by-step design procedure of a filter inductor, highlighting key constraints.

Course Outcome 5 (CO 5)

1. Explain the step-by-step design procedure of a 250 W off-line forward converter, highlighting key design constraints.
2. Describe the procedure to determine the transformer turns ratio for a 500 W push-pull converter.
3. Explain the selection of output capacitor for a 500 W push-pull converter with respect to ripple voltage and ESR.

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: : B24EE3P22

Course Name: : SWITCHED-MODE POWER CONVERTERS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. List any four advantages of SMPS over linear regulators.
2. Distinguish between Continuous Conduction Mode (CCM) and Discontinuous Conduction Mode (DCM) in DC-DC converters.
3. Compare unipolar and bipolar switching schemes in PWM techniques.
4. What is hysteresis control method for PWM generation?
5. Explain the need for galvanic isolation in power converters.
6. Discuss the limitations and disadvantages of flyback converters.
7. List the different types of magnetic devices used in isolated power converters.
8. Define a flyback transformer and state how it differs from a conventional transformer.
9. Why is input capacitor selection critical in off-line SMPS design?
10. State the factors affecting the transformer turns ratio in isolated converters.

PART B

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

11. Compare linear voltage regulators with Switched Mode Power Supplies (SMPS) in terms of efficiency, size, and cost, and explain why SMPS are preferred in high-power applications. (14 marks)

OR

12. Differentiate between Continuous Conduction Mode (CCM) and Discontinuous Conduction Mode (DCM) in boost regulators, and derive the duty ratio for steady-state operation in CCM. (14 marks)
13. Design a compensator for voltage mode control in a buck converter using small-signal techniques, including the selection of poles and zeros to achieve desired phase margin and crossover frequency. (14 marks)

OR

14. Explain the state space averaging technique for modeling second-order switched-mode power converters, and analyze how it simplifies the analysis of buck converters under continuous conduction mode. (14 marks)
15. Describe the basic operation of the forward converter topology, including its circuit schematic, key waveforms. Explain the principle of operation of the push-pull converter and analyze the issue of flux walking, including methods to mitigate it in isolated DC-DC converters. (14 marks)

OR

16. Explain the principle of operation of the push-pull converter and analyze the issue of flux walking, including methods to mitigate it in isolated DC-DC converters. (14 marks)
17. Provide a design example of a filter inductor for a buck converter, detailing the calculations for core size, number of turns, air gap, and verification of saturation limits. (14 marks)

OR

18. Discuss the challenges associated with transformer design in isolated converters, such as leakage inductance, magnetizing current, and core saturation, and explain how they impact converter performance. (14 marks)
19. Analyze the procedure for selecting the output inductor in a 250 W off-line forward converter. (14 marks)

OR

20. Derive the expression for critical inductance that separates CCM and DCM operation in a buck converter. (14 marks)

B24EE3P23	ENERGY MANAGEMENT AND AUDITING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4		

Preamble

The course aims to provide foundational and advanced knowledge on energy management principles, energy conservation techniques, and energy efficiency strategies in electrical and industrial systems. It covers modern approaches in demand side management, energy auditing, and economic evaluation for sustainable energy use. By the end of the course, students will be able to apply energy management concepts, analyze energy systems, and propose energy-efficient solutions in real-world applications.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the principles and planning methods of energy management and DSM techniques. (Cognitive Knowledge Level: Understand)
CO 2	Understand energy-efficient practices in electrical systems such as lighting, motors and transformers to identify opportunities for improving energy efficiency. (Cognitive Knowledge Level: Understand)
CO 3	Apply energy management principles to industrial systems such as boilers, steam distribution, furnaces, HVAC, and heat recovery systems to identify and recommend appropriate energy-saving measures. (Cognitive Knowledge Level: Apply)
CO 4	Apply energy auditing tools and interpret audit results for improving system performance, including cogeneration and combined cycle systems. (Cognitive Knowledge Level: Apply)
CO 5	Apply economic analysis tools to assess the financial viability of energy efficiency projects. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	40	20	20
Understand	60	40	40
Apply		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 (7 hours)

Energy Management - General Principles and Planning

General principles of energy management and energy management planning. Energy conservation in buildings- ECBC code (basic aspects), Building Management System (BMS). Computer aided energy management systems (EMS).

Demand Side Management (DSM)

Introduction to DSM, benefits of DSM, different techniques of DSM –time of day pricing, multi-utility power exchange model, time of day models for planning. Load management, load priority technique, peak clipping, peak shifting, valley filling, strategic conservation, energy efficient equipment. Power factor improvement, numerical examples.

MODULE 2 (8 hours)

Energy Efficiency in Electricity Utilization

Electricity transmission and distribution system, cascade efficiency. Lighting- Modern energy efficient light sources, life and efficacy comparison with older light sources, energy conservation in lighting, use of sensors and lighting automation. Motors- Development of energy efficient motors and the present status, techniques for improving energy efficiency, necessity for load matching and selection of motors for constant and variable loads. Transformers- Present maximum efficiency standards for power and distribution transformers, design measures for increasing efficiency in electrical system components.

MODULE 3 (8 hours)

Energy Management in Industries and Commercial Establishments

Boilers- working principle, blow down, energy conservation opportunities in boilers. Steam- properties of steam, distribution losses, steam trapping. Identifying opportunities for energy savings in steam distribution. Furnace- General fuel economy measures, energy conservation opportunities in furnaces. HVAC system- Performance and saving opportunities in Refrigeration and Air conditioning systems. Heat Recovery Systems- Waste heat recovery system - Energy saving opportunities.

MODULE 4 (7 hours)

Energy Audit

Definition, need, types and methodologies. Instruments for energy audit, Energy audit report - Power quality audit Cogeneration- Need, Application, Types and schemes, optimal operation of cogeneration plants, combined cycle electricity generation.

MODULE 5 (6 hours)

Energy Economics

Economic analysis- methods, cash flow model, time value of money, evaluation of proposals, pay-back period, average rate of return method, internal rate of return method, present value method, life cycle costing approach.

Text Books

1. Albert Thumann, William J. Younger, *Handbook of Energy Audits*, CRC Press, 2003.
2. Charles M. Gottschalk, *Industrial energy conservation*, John Wiley and Sons, 1996.
3. Craig B Smith, *Energy management principles*, Pergamon Press.
4. G G Rajan, *Optimizing energy efficiencies in industry*, Tata McGraw Hill, 2001.
5. Wayne C. Turner, *Energy management Hand Book*, The Fairmount Press, 1997.

Reference Books

1. D. Yogi Goswami, Frank Kreith, *Energy Management and Conservation Handbook*, CRC Press, 2007.
2. M Jayaraju and Premlet, *Introduction to Energy Conservation and Management*, Phasor Books, 2008.
3. Paul O"Callaghan, *Energy management*, McGraw Hill Book.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lec- ture/Tuto- rial Hours
	Total Hours	36 Hours
	Module 1: Energy Management - General Principles and Planning	7
1.1	General principles of energy management and energy management planning	1
1.2	Energy conservation in buildings- ECBC code (basic aspects). Building Management System (BMS). Computer aided energy management systems (EMS)	1
	Demand Side Management (DSM)	

1.3	Introduction to DSM, benefits of DSM, different techniques of DSM –time of day pricing, multi-utility power exchange model, time of day models for planning	2
1.4	Load management, load priority technique, peak clipping, peak shifting, valley filling, strategic conservation, energy efficient equipment	2
1.5	Power factor improvement, numerical examples	1
	Module 2: Energy Efficiency in Electricity Utilization	8
2.1	Electricity transmission and distribution system, cascade efficiency	2
2.2	Energy management opportunities in Lighting: Modern energy efficient light sources, life and efficacy comparison with older light sources, energy conservation in lighting, use of sensors and lighting automation	2
2.3	Energy management opportunities in Motors: Development of energy efficient motors and the present status, techniques for improving energy efficiency, necessity for load matching and selection of motors for constant and variable loads	2
2.4	Transformers: Present maximum efficiency standards for power and distribution transformers, design measures for increasing efficiency in electrical system components	2
	Module 3: Energy Management in Industries and Commercial Establishments	8
3.1	Boilers: working principle - blow down, energy conservation opportunities in boiler	1
3.2	Steam: properties of steam, distribution losses, steam trapping. identifying opportunities for energy savings in steam distribution	2
3.3	Furnace: General fuel economy measures, energy conservation opportunities in furnaces	2
3.4	HVAC system- Performance and saving opportunities in Refrigeration and Air conditioning systems	2
3.5	Heat Recovery Systems- Waste heat recovery system - Energy saving opportunities	1
	Module 4: Energy Audit	7
4.1	Definition, need, types and methodologies	2
4.2	Instruments for energy audit, Energy audit report - Power quality audit	1
4.3	Cogeneration- Need, Application, Types and schemes	2
4.4	Optimal operation of cogeneration plants, combined cycle electricity generation	2
	Module 5: Energy Economics	6
5.1	Economic analysis methods	1
5.2	Cash flow model, time value of money, evaluation of proposals	2

5.3	Pay-back method, average rate of return method, internal rate of return method	2
5.4	Present value method, life cycle costing approach	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Define energy management.
2. List the different phases involved in energy management planning.
3. Discuss the different techniques of DSM.

Course Outcome 2 (CO 2)

1. State the different methods which can be adopted to reduce energy consumption in lighting.
2. Describe how energy consumption can be reduced by energy efficient motors.
3. Discuss the maximum efficiency standards for distribution transformers.

Course Outcome 3 (CO 3)

1. Define Coefficient of performance.
2. Demonstrate how waste heat recovery can be done.
3. Discuss any two opportunities for energy savings in steam distribution.

Course Outcome 4 (CO 4)

1. State the need for energy audit.
2. Discuss the different instruments used for energy audit.
3. Describe how energy consumption can be reduced by cogeneration.

Course Outcome 5 (CO 5)

1. State the need for economic analysis of energy projects.
2. Define payback period.
3. Demonstrate how life cycle costing approach can be used for comparing energy projects.

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: : B24EE3P23

Course Name: : ENERGY MANAGEMENT AND AUDITING

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Write notes on building management systems.
2. Discuss the benefits of demand side management.
3. Compare the efficiency of different light sources.
4. Write notes on design measures for increasing efficiency in transformers.
5. Explain the working of a waste heat recovery system.
6. What are the two sources of feed water in a boiler system? What is the need for feed water treatment?
7. Explain what you mean by power quality audit.
8. Define the term cogeneration. Explain how cogeneration is advantageous over conventional power plant.
9. Compare internal rate of return method with present value method for the selection of energy projects.
10. What are the advantages and disadvantages of the payback period method?

PART B

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

11. (a) With the help of case studies, explain any four energy management principles. (8 marks)
- (b) Explain the different techniques of demand side management. (6 marks)

OR

12. (a) Explain the different phases of energy management planning. (6 marks)
- (b) The load on an installation is 800 kW, 0.8 lagging p.f. which works for 3000 hours per annum. The tariff is Rs 100 per kVA plus 20 paise per kWh. If the power factor is improved to 0.9 lagging by means of loss-free capacitors costing Rs 60 per kVAR, calculate the annual saving effected. Allow 10 % per annum for interest and depreciation on capacitors. (8 marks)
13. (a) Explain any five energy management opportunities in lighting systems. (7 marks)
- (b) What is meant by loading of motor? Why does the efficiency of motor reduce when it operates at lower loading? List down any 2 steps to improve the operating efficiency of under-loaded motors. (7 marks)

OR

14. (a) Elaborate on design measures that can be implemented to enhance the efficiency of transformers. (7 marks)
- (b) Define cascade efficiency. How can it be improved. (7 marks)
15. (a) Explain how energy conservation can be carried out in boilers. (7 marks)
- (b) Identify the energy conservation opportunities in steam distribution. (7 marks)

OR

16. (a) How can energy be saved in a furnace system? (6 marks)
- (b) Explain any five energy saving opportunities in heating, ventilating and air conditioning systems. (8 marks)
17. (a) Discuss how to conduct a detailed energy audit. (7 marks)
- (b) What is an Energy Audit Report? Outline the general format of an Energy Audit. (7 marks)

OR

18. (a) Explain various types of cogeneration systems. (7 marks)
- (b) List out different instruments used for energy audit. Explain the features of any three such instruments. (7 marks)

19. (a) An energy audit in a factory indicates that the total electrical consumption per year is Rs. 5.5×10^6 . By upgrading a few motors with high efficiency motors, a 15 % saving in energy can be realized. The additional cost of energy efficient motors is Rs. 4,25,000 and the installation cost is Rs. 80,000. Assuming a 15 year life cycle, is the expenditure justifiable on a minimum return of 20 %. Conduct an economic analysis using present worth method. (8 marks)
- (b) Differentiate between simple pay back period and net present value method. (6 marks)

OR

20. (a) Explain how the life cycle costing approach can be used for the selection of energy projects. (8 marks)
- (b) Calculate the net present value over a period of 3 years for a project with an initial investment of Rs 50,000 and fuel cost savings of Rs 30,000 in each year. The discount rate is 16 %. (6 marks)

B24EE3P24	SYSTEM DESIGN USING HDL	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course builds a strong foundation in digital system design using VHDL and Verilog, covering structural, behavioral, and dataflow modeling styles. It emphasizes methodology from combinational and sequential logic to finite-state machine design, and guides students through synthesis and FPGA implementation.

Prerequisites

Digital Electronics

Course Outcomes

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

CO 1	Understand the need of HDL in designing of fundamental digital components. (Cognitive knowledge Level: Understand)
CO 2	Apply VHDL techniques to implement dataflow , structural and behavioral model for combinational and sequential circuits. (Cognitive Knowledge Level: Apply)
CO 3	Understand Verilog for modeling combinational and sequential circuits. (Cognitive knowledge Level: Understand)
CO 4	Apply Verilog techniques to implement dataflow, structural and behavioral model for combinational and sequential circuits. (Cognitive Knowledge Level: Apply)
CO 5	To understand the architecture and applications of FPGAs in digital system design. (Cognitive knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	2	1	2		1		1		
CO 2	3	3	3	2	3		1		1		
CO 3	3	3	3	2	3		1		1		
CO 4	3	3	3	2	3		1		1		
CO 5	3	3	3	2	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	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 (6 hours)

Review of Logic Design Fundamentals

Introduction to digital systems-combinational logic- boolean algebra and algebraic simplification - Karnaugh maps, flip-flops and latches, Mealy sequential circuit design, Moore sequential circuit design, tristate logic and busses. Hardware description languages -VHDL description of combinational circuits- modules, sequential statements and VHDL processes, modelling of flip-flops using VHDL processes.

MODULE 2 (8 hours)

Modelling of Digital Systems using VHDL

Dataflow modelling- concept of continuous assignments- syntax, rules and constraints for assigning- operators in dataflow modelling- basic gates -AND, OR, XOR, NOT, half adder, full adder, 2:1 MUX, 4:1 MUX.

Behavioural modelling- syntax, combinational circuits -logic gates, 2:1 multiplexer, 4-bit comparator, half adder, full adder, sequential logic basics - flip-flops (D, T, JK, SR)- clocking and edge detection. Structural modelling basics-component declaration and instantiation-signal connection - hierarchical design-logic gates- 2:1 multiplexer, 4-bit comparator, half adder, full adder, sequential logic basics- flip-flops (D, T, J, SR), finite state machines (FSM) intro (Moore & Mealy).

MODULE 3 (8 hours)

Modelling of Digital Systems using Verilog

Introduction to Verilog HDL - levels of design description, module, language construct and conventions -identifiers, white space, characters, comments, numbers, strings, logic values, data types, scalars and vectors, operators, modelling flip-flops - always block, always blocks using event control statements, Verilog data types and operators.

Gate level modelling- Introduction and gate primitives, module structure, other gate primitives, illustrative examples, tristate gates, design of flip-flops with gate primitives.

MODULE 4 (8 hours)

Modelling of Digital Systems using Verilog

Dataflow level modelling introduction, continuous assignment structure, delays and continuous assignments, assignment to vector, operators, modelling of combinational and se-

quential circuits, behavioural modelling - introduction, operations and assignments, 'initial' construct, always construct, assignments with delays, design at behavioural level- combinational and sequential circuits.

Switch level modelling - basic transistor switches, CMOS switches, bidirectional gates, time delays with switch primitives, instantiation with strengths and delays, switch level modelling - NAND, NOR and XOR

MODULE 5 (6 hours)

Design using FPGA

FPGA - introduction, architecture, application-software familiarisation - layout of the XILINX Artix-7 xc7a35t FPGA, input/output blocks, configurable logic blocks, multiplexer, flip flops. Case study using FPGA software- XILINX.

Text Books

1. M. Morris Mano, Michael D. Ciletti, *Digital Design With an Introduction to the Verilog HDL, VHDL, and System Verilog*, Pearson Education India, 6th ed., 2018.
2. Charles H. Roth, Jr.Lizy Kurian John *Digital Systems Design Using Verilog* , Cengage Learning India Pvt. Ltd., 1st ed., 2017.
3. Charles H. Roth, Jr.Lizy Kurian John *Digital Systems Design Using VHDL* , Cengage Learning India Pvt. Ltd., 3rd ed., 2018.

Reference Books

1. Peter J. Ashenden, *Digital Design - An Embedded System Approach Using VERILOG*, Morgan Kaufmann/Elsevier/Reed Elsevier India, 1st ed., 2007.
2. Nagoor Kani *Digital Logic Circuits with VHDL and Verilog Programs* , CBS Publishers, 1st ed., 2024.
3. Stephen D. Brown & Zvonko.G. Vranesic, *Fundamentals of Digital Logic with Verilog Design*, McGraw Hill Education, 3rd ed., 2013.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Review of Logic Design Fundamentals	6
1.1	Introduction to digital systems, combinational logic basics, boolean algebra–basic laws and theorems	1
1.2	Boolean algebraic simplification techniques, Karnaugh Maps, minimization of logic expressions	1
1.3	Latches – working and truth tables, Flip-flops- operation and timing, clocking, setup, and hold concepts	1
1.4	Tristate buffers their necessity, bus-based data transfer, Enable signals and bus contention	1
1.5	VHDL entity/architecture structure, VHDL for combinational circuits	1
1.6	Sequential statements VHDL processes, Modelling flip-flops in VHDL	1
	Module 2: Modelling of Digital Systems using VHDL	8
2.1	Overview of VHDL, modelling styles, concept of dataflow, continuous assignments, syntax, rules, and operators	1
2.2	Dataflow implementation of AND, OR, XOR, NOT gates, half adder, full adder, 2:1 and 4:1 multiplexer	1
2.3	Behavioural architecture, processes, sensitivity lists, sequential statements (if, case) and conditional assignments	1
2.4	Behavioural description of logic gates, 2:1 multiplexer, 4-bit comparator, half adder, and full adder	1
2.5	Modelling flip-flops (D, T, JK, SR) using processes, clocking concepts, and edge detection	1
2.6	Component declaration, instantiation, port mapping, signal connections, and hierarchical design principles	1
2.7	Building combinational circuits (logic gates, multiplexers, comparators, adders) using structural approach	1
2.8	Structural flip-flops, sequential system design, and introduction to finite state machines (Moore and Mealy).	1
	Module 3: Modelling of Digital Systems using Verilog	8
3.1	Overview of Verilog, levels of design, module structure, language conventions, identifiers, whitespace, comments, and basic syntax	1
3.2	Numbers, strings, logic values, scalars, vectors, data types (wire, reg), and operators (arithmetic, logical, bitwise)	1
3.3	Behavioural modelling using always blocks, event control (posedge, negedge), and flip-flop implementation	1

3.4	Blocking vs non-blocking assignments, modelling D, T, JK, and SR flip-flops, gate primitives: AND, OR, NOT, NAND, NOR, XOR, XNOR, Gate-level module structure, delays, and simple combinational examples	1
3.5	gate primitives: AND, OR, NOT, NAND, NOR, Gate-level module structure, delays, and simple combinational examples	1
3.6	half adder, full adder, and small combinational circuits with gate primitives	1
3.7	Tristate buffers (buff1, buff0), modelling bus connections, and practical examples	1
3.8	Designing flip-flops and latches using gate primitives, timing considerations	1
	Module 4: Modelling of Digital Systems using Verilog	8
4.1	Introduction to Verilog, digital system modeling, levels of abstraction, continuous assignments, vectors, and operators	1
4.2	Dataflow modeling of combinational circuits, use of delays, examples with AND, OR, XOR gates	1
4.3	Dataflow modeling of sequential circuits, flip-flops (D, T, JK), handling clock edges	1
4.4	Introduction to behavioral modeling, initial and always constructs, operations and assignments	1
4.5	Behavioral modeling of combinational circuits, use of delays, case statements, conditional operators	1
4.6	Behavioral modeling of sequential circuits, registers, counters, sensitivity lists	1
4.7	Switch-level modeling basics, nMOS/pMOS, CMOS switches, bidirectional gates, time delays	1
4.8	Switch-level modeling of NAND, NOR, XOR gates, instantiation with strengths and delays	1
	Module 5: Design using FPGA	6
5.1	Introduction to FPGA – advantages, applications, overview of FPGA design flow	1
5.2	FPGA architecture – configurable logic blocks, input/output blocks, flip-flops, multiplexers, interconnects	1
5.3	Xilinx software familiarization – workspace layout, project creation, basic navigation in Artix-7 (xc7a35t) environment	1
5.4	Designing combinational circuits on FPGA – mapping logic to CLBs/IOBs, simulation basics	1
5.5	Designing sequential circuits – flip-flops, registers, counters, timing considerations, simulation	1
5.6	Case study – complete project from RTL design to simulation, generating bit stream, verifying functionality, real-world FPGA applications	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Write the VHDL code for a 2-input AND gate using any one modeling style.
2. Explain the difference between Mealy and Moore sequential circuits.
3. Explain the structure of a VHDL entity and architecture with a suitable example.

Course Outcome 2 (CO 2)

1. Write VHDL code for the following using dataflow modelling: a) Half Adder b) 4:1 Multiplexer.
2. List any three differences between behavioural modelling and structural modelling in VHDL.
3. Compare dataflow, behavioural, and structural modelling in VHDL. Mention one example circuit suitable for each style.

Course Outcome 3 (CO 3)

1. List any three Verilog data types.
2. Describe Verilog language conventions, including identifiers, white space, comments, numbers, and strings
3. Explain the design of flip-flops using gate primitives and the role of tristate gates

Course Outcome 4 (CO 4)

1. What is switch-level modelling?
2. Write Verilog code for: a) 4-bit comparator b) D flip-flop using behavioural modelling.
3. Draw and explain the switch-level model of a 2-input NAND gate with delays.

Course Outcome 5 (CO 5)

1. Explain the layout of the Xilinx Artix-7 xc7a35t FPGA.
2. Name two applications of FPGA.
3. Explain the architecture of an FPGA. Include input/output blocks (IOBs), configurable logic blocks (CLBs), multiplexers, and flip-flops.

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: : B24EE3P24

Course Name: : SYSTEM DESIGN USING HDL

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Write the VHDL code for a 2-input AND gate using any one modeling style.
2. Explain the basic structure of a VHDL module.
3. Compare dataflow, behavioural, and structural modelling in VHDL. Mention one example circuit suitable for each style.
4. Explain briefly the difference between Moore and Mealy FSM in VHDL design.
5. What is a tristate gate, and why is it used?
6. Draw and explain a 2-input NAND gate using gate primitives.
7. Give an example of a sequential circuit implemented using behavioural modelling.
8. What is dataflow modelling in Verilog?
9. Define Input/Output blocks in FPGA.
10. Discuss advantages of using FPGA for digital system design.

PART B

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

11. Write and explain VHDL code for modeling the following flip-flops using process statements: a) D Flip-Flop b) JK Flip-Flop (14 marks)

OR

12. Explain in detail how combinational and sequential digital circuits are modeled in VHDL. (14 marks)
13. (a) What is a 4-bit comparator, and which VHDL modelling style can be used for it? (4 marks)
- (b) Write VHDL code for the following using dataflow modelling: a) Half Adder b) 4:1 Multiplexer. (10 marks)

OR

14. Explain the fundamentals of structural modelling in VHDL. (14 marks)
15. Describe the modeling of sequential circuits in Verilog HDL. (14 marks)

OR

16. Discuss gate-level modeling in Verilog HDL with examples. (14 marks)
17. Design a 4-bit binary adder using Verilog HDL at the dataflow level. (14 marks)

OR

18. Discuss behavioural modelling in Verilog HDL and its application in combinational and sequential circuit design. (14 marks)
19. Explain the layout of the Xilinx Artix-7 xc7a35t FPGA. (14 marks)

OR

20. Explain the architecture of an FPGA. Include input/output blocks (IOBs), configurable logic blocks (CLBs), multiplexers, and flip-flops. (14 marks)

B24EE3P25	COMMUNICATION SYSTEMS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces students to the fundamental principles and technologies that enable efficient signal transmission and reception in both analog and digital domains. It aims to build a solid foundation in communication engineering by developing students' understanding of essential concepts and techniques. Through this course, students will explore the methods and tools commonly used in the design and analysis of communication systems.

Prerequisites

Electronic Circuits I, Electronic Circuits II

Course Outcomes

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

CO 1	Understand and analyze the fundamental structure of communication systems, the necessity of modulation, the impact of noise, and amplitude modulation techniques. (Cognitive Knowledge Level: Understand)
CO 2	Analyse the principles of frequency and phase modulation. (Cognitive Knowledge Level: Apply)
CO 3	Understand the various processing blocks of a digital communication system. (Cognitive Knowledge Level: Apply)
CO 4	Apply the knowledge of digital modulation in digital transmission. (Cognitive Knowledge Level: Apply)
CO 5	Describe the basic principles of satellite communication and radar systems. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	20	20	20
Understand	40	20	40
Apply	40	60	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 (7 hours)

Introduction to Communication Systems

Block diagram of basic communication system, modulation - need for modulation and types of modulation, electromagnetic spectrum and applications. Noise - various types, signal to noise ratio, noise figure.

Amplitude Modulation (AM)

AM signal - equation of amplitude modulated wave, frequency spectrum, Double-Sideband Suppressed Carrier (DSB-SC) modulation, Single Sideband Modulation (SSB), comparison of spectrum, power, and efficiency, amplitude modulator circuits - balanced modulator, AM demodulators - envelope detector.

MODULE 2 (8 hours)

Angle Modulation

Frequency Modulation (FM) - mathematical expression, modulation index, frequency deviation, average power, frequency spectrum, narrow and wide band FM, comparison of AM and FM. FM transmitter - reactance modulator, BJT, FET, Armstrong FM modulator - block schematic. FM receiver - block schematic of superheterodyne FM receiver, FM detector-ratio detector. Phase Modulation (PM) - mathematical representation, relationship between FM and PM.

MODULE 3 (7 hours)

Digital Baseband Communication

Elements of digital communication systems - sources, channels, and receivers, sampling and reconstruction of analog signals, pulse amplitude modulation, pulse width modulation, pulse position modulation, time division multiplexing with PAM, comparison with PWM, and PPM modulation schemes. Pulse code modulation - A-law, mu-law quantisation, differential PCM, delta modulation.

MODULE 4 (7 hours)

Digital Bandpass Communication

Bandpass modulation techniques - amplitude shift keying, phase shift keying, frequency shift keying, methods of generation and detection, signal constellations, M-ary digital modulation schemes, quadrature phase shift keying, minimum shift keying, quadrature amplitude modulation.

MODULE 5 (7 hours)

Satellite Communication

Satellite frequency, geostationary orbits, satellite subsystem - altitude and orbit control - tracking, telemetry and command - power system – transponder – functions - up link/down link converters. multiple access techniques - FDMA, TDMA, CDMA.

Radar

Basic radar system, radar range equation, performance factors, pulsed radar, continuous wave radar, MTI radar system.

Text Books

1. George Kennedy, Bernard Davis, and S. R. M. Prasanna, *Electronic Communication Systems*, McGraw Hill Education, 6th ed., 2017.
2. Wayne Tomasi *Electronic Communication Systems – Fundamentals through Advanced*, Pearson Education, 5th ed., 2008.
3. Simon Haykin and Michael Moher *Communication Systems*, Wiley, 5th ed., 2021.
4. G. K. Mithal *Radio Engineering: Principles of Communication Systems*, Khanna Publishers, 20th ed., 2002.

Reference Books

1. Rodger E. Ziemer and William H. Tranter *Principles of Communications*, Wiley, 7th ed., 2014.
2. J. G. Proakis and M. Salehi *Communication System Engineering*, Pearson Education, 2nd ed., 2018.
3. Leon W. Couch *Digital and Analog Communication Systems*, Prentice Hall, 8th ed., 2012.
4. B. P. Lathi and Zhi Ding *Modern Digital and Analog Communication Systems*, Oxford University Press, 4th ed., 2011.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Communication Systems	7
1.1	Block diagram of basic communication system, modulation, need for modulation and types of modulation	1
1.2	Electromagnetic spectrum and applications, Noise - various types, signal to noise ratio, noise figure	1
	Amplitude Modulation (AM)	
1.3	AM signal, equation of amplitude modulated wave	1
1.4	Frequency spectrum of AM signal, Double-Sideband Suppressed Carrier (DSB-SC) modulation	1
1.5	Single Sideband Modulation (SSB), comparison of spectrum, power, and efficiency	1
1.6	Amplitude modulator circuits - balanced modulator	1
1.7	AM demodulators - envelope detector	1
	Module 2: Angle Modulation	8
2.1	Frequency Modulation (FM) - mathematical expression	1
2.2	Modulation index, frequency deviation, average power, frequency spectrum	1
2.3	Narrow and wide band FM, comparison of AM and FM	1
2.4	FM transmitter - reactance modulator	1
2.5	BJT, FET, Armstrong FM modulator - block schematic.	1
2.6	FM receiver - block schematic of superheterodyne FM receiver	1
2.7	FM detector- ratio detector	1
2.8	Phase Modulation (PM) - mathematical representation, relationship between FM and PM	1
	Module 3: Digital Baseband Communication	7
3.1	Elements of digital communication systems - sources, channels, and receivers	1
3.2	Sampling and reconstruction of analog signals	1
3.3	Pulse amplitude modulation	1
3.4	Time division multiplexing with PAM	1
3.5	Comparison with PWM, and PPM modulation schemes	1
3.6	Pulse code modulation - A-law, mu-law quantisation	1
3.7	Differential PCM, delta modulation	1
	Module 4: Digital Bandpass Communication	7
4.1	Bandpass modulation techniques	1
4.2	Amplitude shift keying, phase shift keying, frequency shift keying	2
4.3	Methods of generation and detection, signal constellations	2

4.4	M-ary digital modulation schemes, quadrature phase shift keying	1
4.5	Minimum shift keying, quadrature amplitude	1
	Module 5: Satellite Communication	7
5.1	Satellite frequency, geostationary orbits, satellite subsystem	1
5.2	Altitude and orbit control - tracking, telemetry and command	1
5.3	Power system, transponder, functions, up link/down link converters	1
5.4	Multiple access techniques - FDMA, TDMA, CDMA	2
	Radar	
5.5	Basic radar system, radar range equation, performance factors, pulsed radar	1
5.6	Continuous wave radar, MTI radar system	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the block diagram of a basic communication system and describe the function of each block with a neat diagram.
2. Discuss the need for modulation in communication systems and classify the different types of modulation, explaining the role of the electromagnetic spectrum in communication applications.
3. Explain amplitude modulation with the help of its mathematical expression and frequency spectrum, and briefly describe the principle of operation of an envelope detector for AM demodulation.

Course Outcome 2 (CO 2)

1. Define frequency modulation (FM) and phase modulation (PM) and write their mathematical expressions.
2. Compare narrowband FM and wideband FM in terms of bandwidth, power efficiency, and spectral characteristics.
3. Calculate the modulation index and frequency deviation for an FM signal given the carrier and modulating frequencies.

Course Outcome 3 (CO 3)

1. List the elements of a digital communication system and describe the role of each component.
2. Explain the difference between PAM, PWM, and PPM modulation techniques and their relative advantages.
3. Determine the quantization levels and bit rate for a given pulse code modulation (PCM) system using μ -law companding.

Course Outcome 4 (CO 4)

1. Identify and define the different digital bandpass modulation techniques and their applications.
2. Explain the concept of signal constellation diagrams for QPSK and QAM and how they help in error detection.
3. Illustrate the signal constellation for a given M-ary PSK signal and explain how the symbols are represented.

Course Outcome 5 (CO 5)

1. List the major subsystems of a satellite and briefly describe the function of each.
2. Explain the differences between FDMA, TDMA, and CDMA multiple access techniques in satellite communication.
3. Using the radar range equation, determine the maximum detection range for a pulsed radar given the transmitted power, antenna gain, and target radar cross-section.

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: : B24EE3P25

Course Name: : COMMUNICATION SYSTEMS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Describe the frequency spectra of SSB and VSB signals.
2. What is the necessity of modulation in communication system?
3. Explain the advantages of FM over AM.
4. Draw the basic block diagram of FM receiver.
5. Differentiate between PPM and PWM.
6. State the significance of Nyquist rate in sampling process.
7. Define Quadrature Amplitude Modulation (QAM). Why is it spectrally efficient?
8. Explain the principle of Amplitude Shift Keying with a neat signal representation.
9. Give comparison between TDMA and FDMA.
10. Explain CDMA referred to satellite communication.

PART B

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

11. Explain Double Sideband Suppressed Carrier (DSB-SC) modulation. Describe its generation using a balanced modulator and discuss its advantages and limitations.

(14 Marks)

OR

12. Derive the expressions for power and efficiency of an AM transmitter. Discuss the effect of modulation index on transmitted power.

(14 Marks)

13. Draw and explain the block schematic of a superheterodyne FM receiver. Describe the function of each block.

(14 Marks)

OR

14. Derive the mathematical expression for a Frequency Modulated wave. Define modulation index and frequency deviation, and explain their significance.

(14 Marks)

15. Explain Differential Pulse Code Modulation with a neat block diagram. Discuss its principle, operation and advantages over PCM.

(14 Marks)

OR

16. Compare PAM, PWM and PPM modulation schemes with respect to bandwidth requirement, noise immunity, power efficiency and complexity.

(14 Marks)

17. With neat block diagrams, explain Quadrature Phase Shift Keying (QPSK). Draw the signal constellation diagram and compare its bandwidth efficiency with BPSK.

(14 Marks)

OR

18. Explain Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), and Phase Shift Keying (PSK). Describe their methods of generation and detection with suitable block diagrams.

(14 Marks)

19. Explain in detail about the satellite uplink and downlink modeling.

(14 Marks)

OR

20. (a) Derive the basic radar range equation, as governed by the minimum receivable echo power, P_{min} .

(9 marks)

- (b) Calculate the maximum range of a radar system which operates at 3 cm, with a peak pulse power of 500 kW, if its minimum receivable power is 10^{-13} W, the capture area of its antenna is 5 m^2 and the radar cross-sectional area of target is 20 m^2 .

(5 marks)

B24EE3P26	DATA STRUCTURES AND ALGORITHMS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course equips learners with a solid foundation in organizing and manipulating data effectively through a variety of data structures. It emphasizes understanding how different structures are organized and how their operations perform in real-world engineering scenarios. Students will explore how these data structures support engineering tasks such as signal processing, control system modeling, network routing, scheduling, and resource allocation within embedded systems.

Prerequisites

NIL

Course Outcomes

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

CO 1	Analyse the time and space efficiency of the data structure. (Cognitive Knowledge Level: Apply)
CO 2	Describe how arrays, records, linked structures, stacks and queues are used in algorithms. (Cognitive Knowledge Level: Understand)
CO 3	Compare and contrast the benefits of dynamic and static data structures implementations. (Cognitive Knowledge Level: Apply)
CO 4	Explain different memory management techniques and their significance. (Cognitive Knowledge Level: Apply)
CO 5	Develop algorithms incorporating trees and graphs. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	2	3	2	1		1	2		2
CO 2	3	3	2	3	2	1		1	2		2
CO 3	3	3	2	3	2	1		1	2		2
CO 4	3	3	2	3	2	1		1	2		2
CO 5	3	3	2	3	2	1		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	50	40	40
Apply	30	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 (6 hours)

Basic Concepts of Data Structures

System life cycle, algorithms, performance analysis, space complexity, time complexity, asymptotic notation, complexity calculation of simple algorithms.

MODULE 2 (8 hours)

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 (8 hours)

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 management - memory allocation and deallocation-first-fit, best-fit and worst-fit allocation schemes.

MODULE 4 (8 hours)

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 (6 hours)

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 & Susan Anderson-Freed, *Fundamentals of Data Structures in C*, Universities Press, 2nd ed., 2008.
2. Vijayalakshmi Pai, *A Textbook of Data Structures and Algorithms: Mastering Nonlinear Data Structures*, Iste/Hermes Science Pub., 1st ed., 2023.
3. Narasimha Karumanchi, *Data Structures and algorithms made easy*, Career monk, 2023.

Reference Books

1. Samanta D, *Classic Data Structures*, Prentice Hall India Learning Private Limited, 2nd ed., 2009.
2. Richard F. Gilberg & Behrouz A. Forouzan, *Data Structures: A Pseudocode Approach with C*, Course Technology Inc, 2nd ed., 2004.
3. Aho A. V., J. E. Hopcroft & J. D. Ullman, *Data Structures and Algorithms*, Pearson Education India, 1st ed., 2002.
4. Tremblay J. P. & P. G. Sorenson, *An Introduction to Data Structures with Applications*, Tata McGraw Hill, 2nd ed., 2017.
5. Peter Brass, *Advanced Data Structures*, Cambridge University Press, 2019.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1:Basic Concepts of Data Structures	6
1.1	System Life Cycle	1
1.2	Algorithms, Performance Analysis	2
1.3	Space Complexity, Time Complexity	1
1.4	Asymptotic Notation (Big O Notation)	1
1.5	Complexity Calculation of Simple Algorithms	1
	Module 2: Arrays and Searching	8
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	2
2.6	Conversion and Evaluation of Expressions	1
2.7	Linear Search and Binary Search	1
	Module 3: Linked List and Memory Management	8
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 and Circular Linked List	1
3.5	Stacks and Queues using Linked List	1
3.6	Polynomial representation using Linked List	1
3.7	Memory allocation and de-allocation-First-fit	1
3.8	Best-fit and Worst-fit allocation schemes	1
	Module 4: Trees and Graphs	8
4.1	Trees, Binary Trees	1
4.2	Binary Tree Representation, Tree Traversals	1
4.3	Binary Search Trees- Binary Search Tree Operations	2
4.4	Graphs, Representation of Graphs	1
4.5	Depth First Search and Breadth First Search on Graphs	2
4.6	Applications of Graphs	1
	Module 5: Sorting and Hashing	6
5.1	Sorting Techniques – Selection Sort, Insertion Sort	1
5.2	Quick Sort, Merge Sort and Heap Sort	1
5.3	Hashing- Hashing Techniques	1
5.4	Collision Resolution, Overflow handling	1
5.5	Hashing functions – Mid square, Division, Folding, Digit Analysis	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. What do you understand by complexity of an algorithm? Write worst case and best case.
2. Find complexity of linear search.
3. Write an algorithm for matrix multiplication and calculate its time complexity.

Course Outcome 2 (CO 2)

1. Explain about the use and representation of header node in linked list.
2. How a linked list can be used to represent the polynomial?
3. What is a circular queue? How it is different from normal queue?

Course Outcome 3 (CO 3)

1. Compare and contrast singly linked list and doubly linked.
2. Compare array and linked list implementation of a general list.
3. What are the disadvantages of representing a linear queue using array and how were they overcome?

Course Outcome 4 (CO 4)

1. Show the memory allocation for a sequence of job requests of size 22K, 10K, 42K, and 31K (in this order) in First Fit, Best Fit and Worst Fit allocation strategies.
2. Explain how memory de-allocation is done in memory management.
3. Compare various memory management techniques.

Course Outcome 5 (CO 5)

1. List the properties of a binary search tree.
2. Develop an algorithm to add an element into a binary search tree.
3. Give any two representations of graph. Give algorithm for DFS. Demonstrate DFS using suitable example.

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: B24EE3P26

Course Name: DATA STRUCTURES AND ALGORITHMS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Compare structured approach and object oriented approach of programming.
2. Calculate the frequency count of the statement $x = x + 1$; in the following code segment
for ($i = 0$; $i < n$; $i++$); for ($j = 0$; $j < n$; $j *= 2$)
 $x = x + 1$;
3. Write an algorithm to reverse a string using stack.
4. Explain the disadvantages of representing a linear queue using array.
5. Write any three applications of linked list.
6. Explain DEQUEUE.
7. Write a non- recursive algorithm for pre-order traversal in a binary tree.
8. What is a binary search tree (BST)? Give an example of a BST with five nodes.
9. Give two different types of representation for graphs.
10. Define selection sort and insertion sort.

PART B

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

11. (a) Explain space complexity and time complexity of an algorithm. Write an algorithm for linear search and mention the best case and worst case time complexity of linear search algorithm. (10 marks)
- (b) Explain modular programming with suitable example. (4 marks)

OR

12. (a) Explain system lifecycle in detail. (10 marks)
- (b) Explain an algorithm. How is its complexity analysed? (4 marks)
13. (a) Write algorithms to insert and delete elements from a double ended queue. Demonstrate with examples. (10 marks)
- (b) Compare and contrast a circular queue with a normal queue. (4 marks)

OR

14. (a) Write an algorithm to evaluate postfix operation. (8 marks)
- (b) Convert the following infix expression into prefix expression $(A-B/C) * (D * E - F)$. Show the stack contents for each step? (6 marks)
15. (a) Write algorithms to perform the following operations on a doubly linked list.
- (i) Insert a node with data 'y' after a node whose data is 'x'.
 - (ii) Delete a node whose data is 's'.
 - (iii) Insert a node with data 'a' as the 1st node of the list. (10 marks)
- (b) Write an algorithm to count the number of occurrences of a character in a linked list. (each node contains only one character) (4 marks)

OR

16. (a) Assume that a Stack is represented using Linked List. Write Algorithms for the following operations.
- a) PUSH b) POP (10 marks)
- (b) Compare a circular linked list and a doubly linked list. (4 marks)
17. (a) Explain how memory de-allocation is done in memory management. (8 marks)
- (b) Discuss the advantages and disadvantages of first-fit, best-fit and worst-fit allocation schemes. (6 marks)

OR

18. (a) Write an pseudocode to perform the following operations on binary search tree.
- i) Insert an element k
 - ii) Search for an element k (10 marks)
- (b) Write an iterative algorithm for in-order traversal of a binary tree. (4 marks)

19. (a) Explain the various ways in which a graph can be represented bringing out the advantages and disadvantages of each representation. (10 marks)
- (b) Write an algorithm to perform bubble sort on a collection of 'n' numbers. (4 marks)

OR

20. (a) Give algorithms for DFS and BFS of a graph and explain with examples. (8 marks)
- (b) How graphs can be represented in a computer. (6 marks)





OPEN ELECTIVE I

B24EE3G11	ELECTRICAL SAFETY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course aims to equip the students with an understanding of the fundamental principles of electrical safety and provide an overview of fundamentals of electrical safety during installations, testing and commissioning procedure. This course conveys knowledge about different equipment in hazardous locations, principle of grounding and concepts of electrical systems safety management.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the objectives and precautions of electrical safety, effects of shocks and their prevention. (Cognitive Knowledge Level: Understand)
CO 2	Acquire knowledge on grounding systems and lightning arresters. (Cognitive Knowledge Level: Apply)
CO 3	Understand the electrical safety during installation, testing and commissioning procedure. (Cognitive Knowledge Level: Apply)
CO 4	Classify different safety equipment for various hazardous locations. (Cognitive Knowledge Level: Apply)
CO 5	Distinguish various fire extinguishers and state the electrical systems safety management. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	1	1	1	1		1	1	1		3
CO 2	3	2	2	1	2		1	1	1		3
CO 3	3	1	3	2	2		1	1	1		3
CO 4	3	1	3	2	2		1	1	1		3
CO 5	3	1	1	1	1	1	2	2	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	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 (8 hours)

Introduction to Electrical Safety

Terms, definitions, objectives of safety, security measures, hazards associated with electric current and voltage, principles of electrical safety.

Electrical Shocks and Prevention

Primary and secondary electrical shocks, possibilities of getting electrical shock and its severity, medical analysis of electric shocks and its effects, AC shocks versus DC shocks, shocks due to flash over, safety precautions against contact shocks, flash shocks, burns.

MODULE 2 (6 hours)

Equipment Earthing (Grounding) and System Neutral Earthing

Distinction between system grounding and equipment grounding, equipment earthing, functional requirements and description of earthing system, neutral grounding (system grounding), types of grounding.

Lightning Arresters

Functions and importance, working principle, construction, classification, performance parameters - breakdown voltage, discharge current capacity, response time, energy absorption capability.

MODULE 3 (7 hours)

Electrical Safety in Residential, Commercial, and Agricultural Installations

Safety during wiring and fitting, safety in domestic appliances - classification and case study - water tap giving shock, shock from wet wall, fan firing shock, commercial installations - multistoried building, case study, temporary installations, agricultural pump installation, do's and don'ts for safety in the use of domestic electrical appliances.

MODULE 4 (7 hours)

Electrical Safety in Hazardous Areas

Introduction, hazardous zones – class 0,1 and 2 spark, flashovers and corona discharge associated with electrical equipment and plants, functional requirements and specifications of electrical plants for hazardous locations, classification of equipment enclosure for various hazardous gases and vapors classification of equipment/enclosure for hazardous locations.

MODULE 5 (8 hours)

Fire Prevention and Fire Fighting

Fundamentals of fire hazards, initiation of fires, classification of fires - class A, class B, class C, class D, class E fires, fire extinguishing techniques, prevention of fire, types of fire extinguishers, fire detection and alarm system.

Safety Management of Electrical Systems

Principles of safety management, management safety policy, safety committee-need, types, advantages, safety organization, safety auditing, role of management, supervisors, workmen, unions, government and voluntary agencies in safety.

Text Books

1. S.Rao, Prof. H.L.Saluja, *Electrical safety, fire safety Engineering and safety management*, Khanna Publishers, 2008.
2. Dennis Neitzel, Al Winfield, *Electrical Safety Handbook*, McGraw-Hill Education, 4th ed., 2012.
3. Cooper.W.F, *Electrical safety Engineering*, Newnes-Butterworth Company, 1978.

Reference Books

1. John Codick, *Electrical safety hand book*, McGraw Hill Inc., 2000.
2. David A. Bell, *Operational Amplifiers & Linear ICs*, Oxford University Press, 3rd ed., 2011.
3. Hughes, *Electrical and Electronic Technology*, Pearson Education.
4. Ray A. Jones and Jane G. Jones, *Electrical safety in the workplace*, Jones & Bartlett Learning, 1st ed., 2000.
5. Maxwell Adams. J, *Electrical safety- a guide to the causes and prevention of electric hazards*, The Institution of Electric Engineers, 1st ed., 1994.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Electrical Safety	8
1.1	Terms and definitions, objectives of safety and security measures	1
1.2	Hazards associated with electric current, and voltage, who is exposed, principles of electrical safety	2
1.3	Primary and secondary electrical shocks, possibilities of getting electrical shock and its severity	2
1.4	Medical analysis of electric shocks and its effects, AC shocks versus DC shocks	1
1.5	Shocks due to flash over, safety precautions against contact shocks, flash shocks, burns	2
	Module 2: Equipment Earthing (Grounding), System Neutral Earthing and Lightning Arresters	6
2.1	Distinction between system grounding and equipment grounding	1
2.2	Equipment earthing, functional requirements and description of earthing system	1
2.3	Neutral grounding (system grounding), types of grounding	1
2.4	Lightning arresters - functions and importance	1
2.5	Working principle, construction, classification lightning arresters	1
2.6	Performance parameters - breakdown voltage, discharge current capacity, response time, energy absorption capability	1
	Module 3: Electrical Safety in Residential, Commercial, and Agricultural Installations	7
3.1	Safety during wiring and fitting	2
3.2	Safety in domestic appliances, classification and case study - Water tap giving shock, shock from wet wall, fan firing shock	1
3.3	Commercial installations –multi-storied building, case study	1
3.4	Temporary installations	1
3.5	Agricultural pump installation	1
3.6	Do's and Don'ts for safety in the use of domestic electrical appliances	1
	Module 4: Electrical Safety in Hazardous Areas	7
4.1	Introduction, classification of hazardous zones –class 0,1 and 2 spark	1
4.2	Flashovers and corona discharge associated with electrical equipment and plants	1

4.3	Functional requirements and specifications of electrical plants for hazardous locations	2
4.4	Classification of equipment enclosure for various hazardous gases and vapours	2
4.5	Classification of equipment/enclosure for hazardous locations	1
	Module 5: Fire Prevention and Fire Fighting, Safety Management of Electrical Systems	8
5.1	Fundamentals of fire hazards, initiation of fires	1
5.2	Classification of fires - class A, B, C, D, E, fire extinguishing techniques	1
5.3	Prevention of fire, types of fire extinguishers	1
5.4	Fire detection and alarm system	1
5.5	Principles of safety management, management safety policy	1
5.6	Safety committee-need, types, advantages, safety organization	1
5.7	Safety organization, safety auditing	1
5.8	Role of management, supervisors, workmen, unions, government and voluntary agencies in safety	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the concepts of electrical safety.
2. Analyze the hazards associated with electric current and voltage.
3. Illustrate shocks and its effects.

Course Outcome 2 (CO 2)

1. Explain the importance of earthing and grounding.
2. Describe requirements of earthing system.
3. Understand working of lightning arresters.

Course Outcome 3 (CO 3)

1. Discuss safety during wiring and fitting.

2. Analyze safety in domestic appliances and installations.
3. Illustrate safety measures using case studies.

Course Outcome 4 (CO 4)

1. Explain safety in hazardous areas.
2. Develop specifications of electrical plants for hazardous locations.
3. Classify equipment enclosures for hazardous gases.

Course Outcome 5 (CO 5)

1. Understand fundamentals of fire hazards.
2. Outline the principle of fire extinguishers.
3. Illustrate role of management in safety.

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: : B24EE3G11

Course Name: : Electrical safety

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Illustrate the physiological effects of electric current on the human body.
2. Define primary and secondary electrical shocks.
3. What is neutral grounding (system grounding)? Explain its significance in electrical safety.
4. Define discharge current capacity of a lightning arrester.
5. What are the common causes of receiving shock from a water tap?
6. What is a temporary electrical installation? Give one example.
7. Define flashover. How does it occur in electrical equipment?
8. State any three functional requirements of electrical equipment used in hazardous locations.
9. Mention three important features of an automatic fire alarm system.
10. Explain “fire triangle” and its relevance to fire initiation.

PART B

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

11. Describe the hazards associated with electric current and voltage. Explain the possible effects on the human body and the risk factors that influence severity. (14 marks)

OR

12. With neat diagrams, explain shock due to flashover. Describe causes, effects, arc flash hazards, and measures to prevent flashover in electrical systems. (14 marks)
13. (a) Differentiate between system grounding and equipment grounding, outlining their respective purposes, significance, and common applications within electrical power systems. (8 marks)
- (b) Describe the performance parameters of a lightning arrester. Explain their significance. (6 marks)

OR

14. Explain with diagrams the complete earthing system in an industrial installation. Include equipment earthing, neutral grounding, and lightning protection. (14 marks)
15. Discuss in detail the importance of RCD/ELCB, proper earthing, insulation, and environmental conditions in preventing electrical accidents at home. Include examples from common domestic shock cases. (14 marks)

OR

16. Explain the safety measures required in commercial installations such as multi-storied buildings. Discuss wiring, load distribution, fire safety, emergency systems, earthing, and maintenance. (14 marks)
17. Compare different enclosure classifications for hazardous locations and explain their suitability for various types of gases and vapours. Include temperature class & gas group. (14 marks)

OR

18. Explain corona discharge and flashover in high-voltage equipment. Discuss their conditions of occurrence, hazards, detection methods, and preventive strategies. (14 marks)
19. Outline various fire extinguishing techniques in detail. Discuss cooling, smothering, starvation, and inhibition methods with suitable examples and applications. (14 marks)

OR

20. Illustrate the role of management, supervisors, workmen, unions, government and voluntary agencies in safety. (14 marks)

B24EE3G12	RENEWABLE POWER GENERATION SYSTEMS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course provides an overview of renewable energy sources and their conversion systems, including solar, wind, biomass, tidal, and small hydro energy. It also gives an insight into hybrid energy systems, energy storage methods, and the current Indian and International energy scenario. The course enables students to apply renewable energy concepts to address future energy challenges.

Prerequisites

Energy Conservation and Environmental Sustainability

Course Outcomes

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

CO 1	Explain environmental impacts of energy, compare conventional and renewable sources, and understand sustainable energy systems including solar thermal technologies and the internet of energy (IoE). (Cognitive knowledge Level: Understand)
CO 2	Apply solar radiation estimation methods and photovoltaic principles to evaluate the performance of standalone and grid connected systems. (Cognitive knowledge Level: Apply)
CO 3	Explain the main components and types of WECS and analyse the characteristics and key issues in grid integration. (Cognitive knowledge Level: Apply)
CO 4	Explain biomass and biogas conversion technologies, tidal energy conversion schemes and small hydro power systems in renewable energy generation. (Cognitive knowledge Level: Understand)
CO 5	Understand different types of hybrid renewable energy sources and identify emerging energy storage technologies. (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	2				2					2
CO 2	3	3	2			2					2
CO 3	3	3	2	1		2					2
CO 4	3	3				2					2
CO 5	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	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 (8 hours)

Introduction to Renewable Energy Systems

Environmental aspects of energy - ecology, greenhouse effect, global warming, pollution - various pollutants and their harmful effects, conventional energy sources and its impacts, importance of renewable energy, energy and sustainable development, availability and their limitations, comparison of conventional and non-conventional energy sources, types of renewable energy sources, present Indian and International energy scenario of conventional and renewable energy sources, introduction to Internet of Energy (IOE).

Solar Thermal Systems

Principle of conversion of solar radiation into heat, solar thermal collectors - flat plate collectors, solar concentrators - parabolic trough, parabolic dish, central tower collector, solar water heater, solar pond electric power plant.

MODULE 2 (7 hours)

Solar Photovoltaic Systems

Solar energy - solar radiation, estimation of solar radiation in horizontal and inclined surfaces, radiation measurement, solar photovoltaic system - photovoltaic effect, equivalent circuit, I-V characteristics, cell, module, array, losses in solar cell, effect of shadowing, series parallel combination of solar cells, cell mismatching, maximum power point tracking, solar photovoltaic system - standalone and grid connected systems, efficiency of PV module.

MODULE 3 (7 hours)

Wind Energy Systems

Availability of wind energy in India, wind speed measurement, basic components of wind energy conversion systems (WECS), classification of WECS - horizontal axis - single, double and multiblade system, vertical axis - Savonius and Darrieus types, wind power equation - Betz limit, problems, power speed and torque speed characteristics of wind turbines, types of generators - induction and synchronous generators, grid integration issues.

MODULE 4 (7 hours)

Renewable Energy Sources: Biomass, Tidal, and Small Hydro

Biomass Energy - biomass conversion technologies, biogas production, classification of biogas plants.

Tidal energy - limitations of tidal energy, tidal energy conversion scheme –single basin and double basin types.

Small hydro - classification of hydro power schemes, types of turbines, essential components of hydroelectric systems, site selection.

MODULE 5 (7 hours)

Hybrid Systems

Need for hybrid systems, type of hybrid systems – diesel-PV, wind-PV, microhydel-PV.

Energy Storage Systems

Introduction, need for energy storage systems, pumped storage, compressed air storage, fly-wheel storage, battery storage- types, charging methodologies, hydrogen storage. Emerging technologies - fuel cell, hydrogen energy, alcohol energy, and power from satellite stations.

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. Sawhney G. S., *Non-Conventional Energy Resources*, PHI Learning, 2012.

Reference Books

1. G.N. Tiwari, *Solar Energy-Fundamentals, Design, Modelling and Applications*, , Narosa Publishers, 2002.
2. Earnest J. and T. Wizelius, *Wind Power Plants and Project Development*, PHI Learning, 2nd ed., 2017.
3. Sab S. L., *Renewable and Novel Energy Sources*, MI. Publications, 1995.
4. Tiwari G. N., *Solar Energy- Fundamentals, Design, Modelling and Applications*, CRC Press, 2002.
5. A. A. M. Saigh (Ed), *Solar Energy Engineering*, Academic Press, 1977.
6. Abbasi S. A. and N. Abbasi, *Renewable Energy Sources and Their Environmental Impact*, Prentice Hall of India, 2001.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Renewable Energy Systems	8
1.1	Environmental aspects of energy - ecology, greenhouse effect, global warming, pollution - various pollutants and their harmful effects	1
1.2	Conventional energy sources and its impacts, importance of renewable energy, energy and sustainable development	1
1.3	Availability and their limitations, comparison of conventional and non-conventional energy sources, types of renewable energy sources	1
1.4	Present Indian and International energy scenario of conventional and renewable energy sources	1
1.5	Introduction to Internet of Energy(IOE)	1
	Solar Thermal Systems	
1.6	Principle of conversion of solar radiation into heat, solar thermal collectors- flat plate collectors	1
1.7	Solar concentrators - parabolic trough, parabolic dish, central tower collector	1
1.8	Solar water heater, solar pond electric power plant	1
	Module 2: Solar Photovoltaic Systems	7
2.1	Solar energy - solar radiation, estimation of solar radiation in horizontal and inclined surfaces,	1
2.2	Radiation measurement, solar photovoltaic system - photovoltaic effect	1
2.3	Equivalent circuit, I-V characteristics, cell, module, array	1
2.4	Losses in solar cell, effect of shadowing, series parallel combination of solar cells, cell mismatching	1
2.5	Maximum power point tracking	1
2.6	solar photovoltaic system - standalone and grid connected systems	1
2.7	Efficiency of PV module	1
	Module 3: Wind Energy Systems	7
3.1	Availability of wind energy in India, wind speed measurement	1
3.2	Basic components of wind energy conversion systems	1
3.3	Classification of WECS - horizontal axis - single, double and multiblade system, vertical axis - Savonius and Darrieus types	1
3.4	Wind power equation - Betz limit, problems	1
3.5	Power speed and torque speed characteristics of wind turbines	1

3.6	Types of generators – induction and synchronous generators	1
3.7	Grid integration issues	1
	Module 4: Renewable Energy Sources: Biomass, Tidal, and Small Hydro	7
4.1	Biomass Energy - biomass conversion technologies, biogas production	1
4.2	Classification of biogas plants	1
4.3	Tidal energy - limitations of tidal energy	1
4.4	Tidal energy conversion scheme –single basin and double basin types	1
4.5	Small hydro - classification of hydro power schemes	1
4.6	Types of turbines	1
4.7	Essential components of hydroelectric systems, site selection	1
	Module 5: Hybrid Systems	7
5.1	Need for hybrid systems, type of hybrid systems – diesel-PV	1
5.2	Wind-PV, microhydel-PV	1
	Energy Storage Systems	
5.3	Introduction, need for energy storage systems, pumped storage	1
5.4	Compressed air storage, flywheel storage	1
5.5	Battery storage- types, charging methodologies, hydrogen storage	1
5.6	Emerging technologies - fuel cell, hydrogen energy	1
5.7	Alcohol energy, and power from satellite stations	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Compare conventional and non conventional sources of energy.
2. Explain the importance of renewable energy for sustainable development.
3. State the principle of conversion of solar radiation into heat.

Course Outcome 2 (CO 2)

1. Discuss the effect of shadowing on the performance of solar cells.
2. Design of stand-alone PV system.

3. Derive an expression for PV module efficiency and specify any 3 factors affecting module efficiency.

Course Outcome 3 (CO 3)

1. State and derive the wind power equation.
2. Problems based on wind power equation.
3. Explain the Savonius wind turbine with a neat diagram.

Course Outcome 4 (CO 4)

1. Describe the process of biogas production.
2. Compare single-basin and double-basin tidal plants.
3. Explain the working principle of a Pelton turbine.

Course Outcome 5 (CO 5)

1. Discuss on compressed air energy storage.
2. Summarize hydrogen storage methods and its role in future renewable energy systems.
3. Explain the operation of a fuel cell.

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: : B24EE3G12

Course Name: : RENEWABLE POWER GENERATION SYSTEMS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Write notes on Indian energy scenario.
2. Identify the various pollutants and briefly mention their harmful effects.
3. Draw and explain the equivalent circuit model of a solar cell.
4. List the different types of losses in a solar PV system.
5. Define Betz limit and its significance.
6. State the common grid integration issues with wind turbines.
7. Explain biomass conversion technologies.
8. Discuss any three limitations of tidal energy.
9. List the advantages of hybrid renewable systems.
10. Explain pumped storage method with a neat diagram.

PART B

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

11. (a) Differentiate between flat plate collectors and solar concentrators.
(6 marks)
- (b) Explain the working principle and components of a solar water heating system. Also discuss its advantages and disadvantages.
(8 marks)

OR

12. (a) Explain global warming in detail. Discuss its causes, effects, and control measures.
(7 marks)
- (b) Describe the architecture and working principle of Internet of Energy (IoE).
(7 marks)
13. (a) Illustrate how maximum power point tracking is done on a solar photovoltaic system.
(10 marks)
- (b) Compare standalone and grid-connected PV systems.
(4 marks)

OR

14. (a) Explain the methods of estimating solar radiation on horizontal and inclined surfaces.
(10 marks)
- (b) Draw and explain the I–V characteristics of a solar cell.
(4 marks)
15. (a) With a neat diagram, describe the basic components of a Wind energy conversion system.
(7 marks)
- (b) Explain various horizontal-axis wind turbine (HAWT) configurations.
(7 marks)

OR

16. (a) Compare induction and synchronous generators for WECS.
(8 marks)
- (b) Describe the working principle of an anemometer for wind speed measurement.
(6 marks)
17. With a neat diagram, describe the essential components of a small hydroelectric power system and list the main factors involved in selecting a site for a small hydro plant.
(14 marks)

OR

18. (a) Discuss the double-basin tidal energy conversion scheme. (6 marks)
- (b) Summarize the different types of turbines used in hydro power. (8 marks)
19. (a) Explain different types of batteries used in energy storage and their charging methodologies. (14 marks)

OR

20. (a) Describe flywheel energy storage and its applications. (8 marks)
- (b) Give a detailed note on the concept of solar power satellite. (6 marks)

B24EE3G13	ELECTRICAL POWER UTILIZATION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course aims to equip the students to attain industry identified competency through various teaching learning experiences. The subject conveys the principles and applications of Illumination engineering, Electrolysis Process, Refrigeration and Air Conditioning, Electrical Traction and Heating and Electric vehicles. This course will enable the students to make proper selection of equipment according to requirement to ensure economical and efficient use of electricity

Prerequisites

Nil

Course Outcomes

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

CO 1	Apply principles of electrical energy utilization to evaluate and implement traction systems considering economic feasibility and recent technological advancements. (Cognitive knowledge Level: Apply)
CO 2	Summarize the economic benefits and environmental impacts of electric heating systems. (Cognitive knowledge Level: Understand)
CO 3	Apply illumination principles to calculate and design illumination levels for lighting systems, and use LED drive circuits by considering their operating characteristics. (Cognitive knowledge Level: Apply)
CO 4	Describe the operating conditions and environmental factors affecting refrigeration and air-conditioning systems. (Cognitive knowledge Level: Understand)
CO 5	Acquire basic knowledge about electric vehicles and drives. (Cognitive knowledge Level: Remember)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	2	2	1	2					1
CO 2	3	3	3	2	1	3					1
CO 3	3	3	3	2	1	2					1
CO 4	3	3	2	2	1	2					1
CO 5	3	2	2	1	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/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 (8 hours)

Electric Traction

Ideal traction system - systems of electric traction, mechanism of train movement - speed-time curve, tractive effort, traction motors - speed control schemes, traction supply system - current collection systems, transmission and distribution system, modern electric traction and drives, electric braking, challenges in electric traction, technology upgradation in electric traction.

MODULE 2 (7 hours)

Electric Heating

Classification of electric heating methods - resistance heating, arc furnace - radiant heating, induction heating, high frequency eddy current heating, dielectric heating, electric ovens, domestic water heaters, and other heating appliances and thermostat control circuit.

Electric Welding

Classification of welding processes - resistance welding, electric arc welding, ultrasonic welding, electron beam welding, laser beam welding.

MODULE 3 (8 hours)

Illumination

Terms and definitions - coefficient of utilization, depreciation factor, reflection factor, laws of illumination, luminous efficacy, sources of light - arc lamps, carbon arc lamp, flame arc lamp, incandescent lamp, discharge lamps - sodium vapor discharge lamp, high-pressure mercury vapor discharge lamp, neon lamp, fluorescent tube, CFL, design of lighting schemes - illumination levels for various purposes, factory lighting, street lighting and flood lighting, LED lamps, comparison between tungsten filament lamps, fluorescent lamps and LED lamps.

MODULE 4 (7 hours)

Refrigeration and Air-conditioning

Refrigeration cycle, vapour compression refrigeration system, refrigerants, domestic refrigerator and water coolers, air conditioning - air conditioning cycle, classification of air conditioning systems - central system, unitary systems, load estimation - cooling load estimate, heating load estimate, internal heat gains, heating of building - types of heating equipment used for space heating, smart air conditioning units, energy efficient motors, standard motor efficiency, need for more efficient motors.

MODULE 5 (6 hours)

Electric Vehicles

Electric Vehicle Technology - requirements, comparative performance of IC engine and EV, types of EV and components - electric motor, battery pack, inverter, transmission and drive system, summary of motor selection, energy loss in various drive cycles.

Text Books

1. J. B. Gupta, *Utilization of electric power and electric traction*, SK Katsons, 2013.
2. R. K. Rajput, *Utilization of electrical power*, Laxmi Publications, 2006.
3. D. N. V. Suryanarayana, *Utilisation of Electric Power*, Wiley Eastern/New Age International Publications, 2017.

Reference Books

1. Wadhwa. C.L., *Generation, Distribution and utilization of electrical energy*, Wiley Eastern Limited, 2008.
2. William E.Dewitt, *Electric Power and Control*, 2nd ed., Pearson, 2013.
3. J Marcos Alonso, *LED Lighting and Drivers*, 2019.
4. Sunil S Rao, *Utilization, Generation and Conservation of Electrical Energy*, Khanna Publishers, 1st ed., 2011.
5. H.Pratab, *Art and Science of Utilisation of Electrical Energy*, Dhanpat Rai and Co.
6. G. C. Garg, *Utilization of Electric Power and Electric Traction*, Khanna Publishers 9th ed., 2014.
7. Iqbal Husain *Electric and Hybrid Vehicles*, CRC Press, 2024.
8. Amir Khajepour, Saber Fallah and Avesta Goodarzi, *Electric and Hybrid Vehicles Technologies, Modeling and Control: A Mechatronic Approach*, John Wiley and Sons Ltd., 2014.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Electric Traction	8
1.1	Ideal traction system and systems of electric traction	1
1.2	Mechanism of train movement speed-time curve	1
1.3	Concept of tractive effort, traction motors	1
1.4	Speed control schemes and traction supply system	1
1.5	Current collection systems, transmission and distribution system	2
1.6	Modern electric traction and drives and electric braking	1
1.7	Challenges in electric traction, technology upgradation in electric traction	1
	Module 2: Electric Heating	7
2.1	Classification of electric heating methods, resistance heating, arc furnace	1
2.2	Radiant heating, induction heating and high frequency eddy current heating	1
2.3	Dielectric heating, electric ovens, domestic water heaters	1
2.4	Other heating appliances and thermostat control circuit	1
	Electric Welding	
2.5	Classification of welding processes, resistance welding	1
2.6	Electric arc welding and ultrasonic welding	1
2.7	Electron beam welding and laser beam welding	1
	Module 3: Illumination	8
3.1	Terms and definitions - coefficient of utilization, depreciation factor, reflection factor	1
3.2	Laws of illumination, luminous efficacy, sources of light - arc lamps, carbon arc lamp	1
3.3	Flame arc lamp, incandescent lamp, discharge lamps -	1
3.4	Sodium vapor discharge lamp and high-pressure mercury vapor discharge lamp	1
3.5	Neon lamp, fluorescent tube, CFL	1
3.6	Design of lighting schemes - illumination levels for various purposes, factory lighting	1
3.7	Street lighting and flood lighting, LED lamps	1
3.8	Comparison between tungsten filament lamps, fluorescent lamps and LED lamps	1
	Module 4: Refrigeration and Air-conditioning	7
4.1	Refrigeration cycle, vapour compression refrigeration system	1
4.2	Refrigerants, domestic refrigerator and water coolers	1
4.3	Air conditioning - air conditioning cycle	1

4.4	Classification of air conditioning systems - central system, unitary systems	1
4.5	Load estimation - cooling load estimate, heating load estimate	1
4.6	Internal heat gains, heating of building - types of heating equipment used for space heating, smart air conditioning units	1
4.7	Energy efficient motors, standard motor efficiency, need for more efficient motors	1
	Module 5: Electric Vehicles	6
5.1	Electric Vehicle Technology - requirements	1
5.2	Comparative performance of IC engine and EV	1
5.3	Types of EV and components - electric motor	1
5.4	Battery pack and inverter	1
5.5	Transmission and drive system	1
5.6	Summary of motor selection, energy loss in various drive cycles	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Select the relevant track electrification system for the specified traction services with justification.
2. Draw the speed - time curve for the specified electric traction application.
3. Differentiate between the given types of traction services based on the given criteria.

Course Outcome 2 (CO 2)

1. Explain construction, working principle and classification of the specified electrical heating system.
2. Design the heating element of the given type of furnace from the specified data.
3. Select the relevant welding system for the specified application with justification.

Course Outcome 3 (CO 3)

1. Define the given term(s) as related to illumination.
2. Explain the construction and working of the given type of lamp(s) and lamp fittings.

3. Design simple lighting scheme for the given data.

Course Outcome 4 (CO 4)

1. Analyze the working of a domestic refrigerator and water cooler; explain performance differences.
2. Compare different types of heating equipment used for space heating and analyze their suitability for commercial buildings.
3. Analyze how smart air conditioning units improve energy efficiency.

Course Outcome 5 (CO 5)

1. Explain the functional components of an EV drive system with a neat block diagram.
2. Explain the regenerative braking process used in electric vehicles.
3. Explain the necessity of power converters in EV drive systems.

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: : B24EE3G13

Course Name: : ELECTRICAL POWER UTILIZATION

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define tractive effort. Why is it a critical factor in train movement?
2. Mention three challenges in electric traction faced in modern railways.
3. State the function of a thermostat control circuit in heating appliances.
4. Differentiate between electron beam welding and laser beam welding.
5. State the laws of illumination.
6. Define luminous efficacy and give its unit.
7. What is the principle of a vapour compression refrigeration system?
8. What are internal heat gains in air conditioning?
9. List two differences between IC engine vehicles and electric vehicles.
10. What is the role of the battery pack in electric vehicles?

PART B

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

11. (a) With a neat sketch, describe the speed–time curve of train movement and its different phases. (7 marks)
(b) Explain different types of electric braking used in traction systems. (7 marks)

OR

12. Explain the traction supply system with neat diagrams. Describe transmission and distribution arrangements for electric traction. (14 marks)
13. (a) Discuss the construction and working of electric ovens. (7 marks)
(b) Describe the working principle of resistance welding and its applications. (7 marks)

OR

14. (a) Explain high-frequency eddy current heating with advantages and limitations. (7 marks)
(b) Discuss the principle, construction, and applications of ultrasonic welding. (7 marks)
15. (a) Explain the requirements and design considerations for street lighting. (7 marks)
(b) Explain the importance of coefficient of utilization, depreciation factor, and reflection factor in illumination design. (7 marks)

OR

16. (a) Discuss the design of lighting schemes for factory lighting. (7 marks)
(b) Describe the working principle and applications of sodium vapor discharge lamp. (7 marks)
17. (a) Classify air conditioning systems into central and unitary systems with examples. (7 marks)
(b) Explain the role of smart air conditioning units in modern energy management. (7 marks)

OR

18. (a) Explain the different types of heating equipment used for space heating. (7 marks)
(b) Explain the procedure for cooling load estimation in air conditioning design. (7 marks)
19. (a) Compare the performance of IC engine vehicles and EVs with respect to efficiency, emissions, and maintenance. (7 marks)
(b) Discuss the requirements and criteria for choosing suitable traction motors in EV applications. (7 marks)

OR

20. (a) Explain the importance of transmission and drive systems in electric vehicles. (6 marks)
(b) Describe the types of electric vehicle with examples. (8 marks)

B24EE3G14	ENERGY MANAGEMENT AND AUDITING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The course aims to provide foundational and advanced knowledge on energy management principles, energy conservation techniques, and energy efficiency strategies in electrical and industrial systems. It covers modern approaches in demand side management, energy auditing, and economic evaluation for sustainable energy use. By the end of the course, students will be able to apply energy management concepts, analyze energy systems, and propose energy-efficient solutions in real-world applications.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the principles and planning methods of energy management and DSM techniques. (Cognitive Knowledge Level: Understand)
CO 2	Understand energy-efficient practices in electrical systems such as lighting and motors to identify opportunities for improving energy efficiency. (Cognitive Knowledge Level: Understand)
CO 3	Apply energy management principles to industrial systems such as boilers, steam distribution, furnaces, HVAC, and heat recovery systems to identify and recommend appropriate energy-saving measures. (Cognitive Knowledge Level: Apply)
CO 4	Apply energy auditing tools and interpret audit results for improving system performance, including cogeneration and combined cycle systems. (Cognitive Knowledge Level: Apply)
CO 5	Apply economic analysis tools to assess the financial viability of energy efficiency projects. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	40	20	20
Understand	60	40	40
Apply		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 (8 hours)

Energy Management - General Principles and Planning

General principles of energy management and energy management planning. Energy conservation in buildings- ECBC code (basic aspects), Building Management System (BMS). Computer aided energy management systems (EMS).

Demand side Management (DSM)

Introduction to DSM, benefits of DSM, different techniques of DSM –time of day pricing, multi-utility power exchange model, time of day models for planning. Load management, load priority technique, peak clipping, peak shifting, valley filling, strategic conservation, energy efficient equipment. Power factor improvement, numerical examples.

MODULE 2 (7 hours)

Energy Efficiency in Electricity Utilization

Electricity transmission and distribution system, cascade efficiency. Lighting- Modern energy efficient light sources, life and efficacy comparison with older light sources, energy conservation in lighting, use of sensors and lighting automation. Motors- Development of energy efficient motors and the present status, techniques for improving energy efficiency, necessity for load matching and selection of motors for constant and variable loads.

MODULE 3 (8 hours)

Energy Management in Industries and Commercial Establishments

Boilers- working principle, blow down, energy conservation opportunities in boilers. Steam- properties of steam, distribution losses, steam trapping. Identifying opportunities for energy savings in steam distribution. Furnace- General fuel economy measures, energy conservation opportunities in furnaces. HVAC system- Performance and saving opportunities in Refrigeration and Air conditioning systems. Heat Recovery Systems- Waste heat recovery system - Energy saving opportunities.

MODULE 4 (7 hours)

Energy Audit

Definition, need, types and methodologies. Instruments for energy audit, Energy audit report - Power quality audit Cogeneration- Need, Application, Types and schemes, optimal operation of cogeneration plants, combined cycle electricity generation.

MODULE 5 (6 hours)

Energy Economics

Economic analysis- methods, cash flow model, time value of money, evaluation of proposals, pay-back period, average rate of return method, internal rate of return method, present value method, life cycle costing approach.

Text Books

1. Albert Thumann, William J. Younger, *Handbook of Energy Audits*, CRC Press, 2003.
2. Charles M. Gottschalk, *Industrial energy conservation*, John Wiley and Sons, 1996.
3. Craig B Smith, *Energy management principles*, Pergamon Press.
4. G G Rajan, *Optimizing energy efficiencies in industry*, Tata McGraw Hill, 2001.
5. Wayne C. Turner, *Energy management Hand Book*, the Fairmount Press, 1997.

Reference Books

1. D. Yogi Goswami, Frank Kreith, *Energy Management and Conservation Handbook*, CRC Press, 2007.
2. M Jayaraju and Premlet, *Introduction to Energy Conservation and Management*, Phasor Books, 2008.
3. Paul O"Callaghan, *Energy management*, McGraw Hill.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Energy Management - General Principles and Planning	8
1.1	General principles of energy management and energy management planning	1
1.2	Energy conservation in buildings- ECBC code (basic aspects). Building Management System (BMS). Computer aided energy management systems (EMS)	2
	Demand Side Management (DSM)	

1.3	Introduction to DSM, benefits of DSM, different techniques of DSM –time of day pricing, multi-utility power exchange model, time of day models for planning	2
1.4	Load management, load priority technique, peak clipping, peak shifting, valley filling, strategic conservation, energy efficient equipment	2
1.5	Power factor improvement, numerical examples	1
	Module 2: Energy Efficiency in Electricity Utilization	7
2.1	Electricity transmission and distribution system, cascade efficiency	2
2.2	Energy management opportunities in Lighting: Modern energy efficient light sources, life and efficacy comparison with older light sources, energy conservation in lighting, use of sensors and lighting automation	2
2.3	Energy management opportunities in Motors: Development of energy efficient motors and the present status, techniques for improving energy efficiency	2
2.4	Necessity for load matching and selection of motors for constant and variable loads	1
	Module 3: Energy Management in Industries and Commercial Establishments	8
3.1	Boilers: working principle - blow down, energy conservation opportunities in boiler	1
3.2	Steam: properties of steam, distribution losses, steam trapping. identifying opportunities for energy savings in steam distribution	2
3.3	Furnace: General fuel economy measures, energy conservation opportunities in furnaces	2
3.4	HVAC system- Performance and saving opportunities in Refrigeration and Air conditioning systems	2
3.5	Heat Recovery Systems- Waste heat recovery system - Energy saving opportunities	1
	Module 4: Energy Audit	7
4.1	Definition, need, types and methodologies	2
4.2	Instruments for energy audit, Energy audit report - Power quality audit	1
4.3	Cogeneration- Need, Application, Types and schemes	2
4.4	Optimal operation of cogeneration plants, combined cycle electricity generation	2
	Module 5: Energy Economics	6
5.1	Economic analysis methods	1
5.2	Cash flow model, time value of money, evaluation of proposals	2
5.3	Pay-back method, average rate of return method, internal rate of return method	2
5.4	Present value method, life cycle costing approach	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Define energy management.
2. List the different phases involved in energy management planning.
3. Discuss the different techniques of DSM.

Course Outcome 2 (CO 2)

1. State the different methods which can be adopted to reduce energy consumption in lighting.
2. Describe how energy consumption can be reduced by energy efficient motors.
3. Compare the efficiency of different light sources.

Course Outcome 3 (CO 3)

1. Define Coefficient of performance.
2. Demonstrate how waste heat recovery can be done.
3. Discuss any two opportunities for energy savings in steam distribution.

Course Outcome 4 (CO 4)

1. State the need for energy audit.
2. Discuss the different instruments used for energy audit.
3. Describe how energy consumption can be reduced by cogeneration.

Course Outcome 5 (CO 5)

1. State the need for economic analysis of energy projects.
2. Define payback period.
3. Demonstrate how life cycle costing approach can be used for comparing energy projects.

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: : B24EE3G14

Course Name: : ENERGY MANAGEMENT AND AUDITING

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Write notes on building management systems.
2. Discuss the benefits of demand side management.
3. Compare the efficiency of different light sources.
4. Explain the energy management opportunities in motors.
5. Explain the working of a waste heat recovery system.
6. What are the two sources of feed water in a boiler system? What is the need for feed water treatment?
7. Explain what you mean by power quality audit.
8. Define the term cogeneration. Explain how cogeneration is advantageous over conventional power plant.
9. Compare internal rate of return method with present value method for the selection of energy projects.
10. What are the advantages and disadvantages of the payback period method?

PART B

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

11. (a) With the help of case studies, explain any four energy management principles. (8 marks)
- (b) Explain the different techniques of demand side management. (6 marks)

OR

12. (a) Explain the different phases of energy management planning. (6 marks)
- (b) The load on an installation is 800 kW, 0.8 lagging p.f. which works for 3000 hours per annum. The tariff is Rs 100 per kVA plus 20 paise per kWh. If the power factor is improved to 0.9 lagging by means of loss-free capacitors costing Rs 60 per kVAR, calculate the annual saving effected. Allow 10 percentage per annum for interest and depreciation on capacitors. (8 marks)
13. (a) Explain any five energy management opportunities in lighting systems. (7 marks)
- (b) What is meant by loading of motor? Why does the efficiency of motor reduce when it operates at lower loading? List down any 2 steps to improve the operating efficiency of under-loaded motors. (7 marks)

OR

14. (a) Explain the use of sensors and lighting automation in reducing energy consumption. (7 marks)
- (b) Define cascade efficiency. How can it be improved. (7 marks)
15. (a) Explain how energy conservation can be carried out in boilers. (7 marks)
- (b) Identify the energy conservation opportunities in steam distribution. (7 marks)

OR

16. (a) How can energy be saved in a furnace system? (6 marks)
- (b) Explain any five energy saving opportunities in heating, ventilating and air conditioning systems. (8 marks)
17. (a) Discuss how to conduct a detailed energy audit. (7 marks)
- (b) What is an Energy Audit Report? Outline the general format of an Energy Audit. (7 marks)

OR

18. (a) Explain various types of cogeneration systems. (7 marks)
- (b) List out different instruments used for energy audit. Explain the features of any three such instruments. (7 marks)

19. (a) An energy audit in a factory indicates that the total electrical consumption per year is Rs. 5.5×10^6 . By upgrading a few motors with high efficiency motors, a 15 percentage saving in energy can be realized. The additional cost of energy efficient motors is Rs. 4,25,000 and the installation cost is Rs. 80,000. Assuming a 15 year life cycle, is the expenditure justifiable on a minimum return of 20 %. Conduct an economic analysis using present worth method. (8 marks)
- (b) Differentiate between simple pay back period and net present value method. (6 marks)

OR

20. (a) Explain how the life cycle costing approach can be used for the selection of energy projects. (8 marks)
- (b) Calculate the net present value over a period of 3 years for a project with an initial investment of Rs 50,000 and fuel cost savings of Rs 30,000 in each year. The discount rate is 16 %. (6 marks)

B24EE3G15	INDUSTRIAL AUTOMATION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The aim of this course is to provide a comprehensive understanding of automation and industrial control systems, focusing on the principles, technologies, and applications that drive modern manufacturing and process industries. The course covers principles of automation, industrial sensors and actuators, virtual instrumentation, programmable logic controllers, and supervisory and distributed control systems along with standard communication protocols. Upon completion, students will be able to comprehend, analyze, and apply fundamental automation and control concepts in industrial environments.

Prerequisites

Nil

Course Outcomes

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

CO 1	Describe the architecture of automated systems, automation strategies and fundamental concepts of Industrial control systems. (Cognitive knowledge level: Understand)
CO 2	Select a suitable sensor for the given application based on the evaluation of the constraints. (Cognitive knowledge level: Apply)
CO 3	Identify a suitable actuator system for the given application based on the evaluation of the constraints and to explain the architecture of Virtual Instrumentation System. (Cognitive knowledge level: Understand)
CO 4	Develop the logic for the process control applications using PLC programming. (Cognitive knowledge level: Apply)
CO 5	Explain the fundamental concepts of DCS and SCADA systems and Identify communication protocol for an industrial process. (Cognitive knowledge level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	2	2	2	1	1	1	1				2
CO 2	3	2	2	1		1	1				2
CO 3	3	2	3	1	3	1	1				2
CO 4	3	2	3	1	3	1	1				2
CO 5	2	2	2	1	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	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 (8 hours)

Introduction to Automation and Industrial Control Systems

Introduction to automation - definition of automation, reasons for automating, types of automated manufacturing systems, automation principles and strategies, basic elements of automated system, advanced automation functions, levels of automation.

Industrial control systems - process and discrete manufacturing industries, continuous and discrete control systems, overview of computer process control, control requirements, capabilities of computer control, forms of computer process control - DDC, CNC, PLC, SCADA, DCS.

MODULE 2 (6 hours)

Sensors

Configuration of the process control system, Sensors - thermal sensors-RTDs, thermistors, thermocouples. Mechanical sensors - LVDT, load cell, metal strain gauges, piezoelectric accelerometer, bourdon tube, solid state pressure sensors, optical sensors - photovoltaic detectors, photo-emissive detector, hall effect sensor - basic working principle and construction. Micro electromechanical system (MEMS), advantages and applications, MEMS micro sensors and actuators, MEMS accelerometers.

MODULE 3 (6 hours)

Actuators and Control Elements

Final control operation - elements of final control operation, signal conversion. Actuators - electric actuators - DC motors, synchronous motors, induction motors, stepper motors, rotary to linear motion conversion, linear motors, solenoid-electromechanical relay, hydraulic and pneumatic actuators, piezoelectric actuator.

Control elements - mechanical, electrical, fluid valves.

Virtual Instrumentation System

Architecture of virtual instruments, virtual instruments and traditional instruments, concepts of graphical programming.

MODULE 4 (8 hours)

Programmable Logic Controllers (PLC)

Introduction to PLC, hardware details, internal architecture, PLC input and output devices, series and parallel communications - protocols.

Introduction to IEC 61131 standard - ladder programming, realization of logic functions, concept of latching, introduction to timer/counters, exercises based on timers and counters.

MODULE 5 (8 hours)

SCADA and DCS Systems

Supervisory Control and Data Acquisition (SCADA) - introduction, SCADA architecture, common system components, supervision and control, HMI, RTU, supervisory stations, Protocols - IEC 60870-5-101 and IEC 60870-5-104 .

Distributed Control System (DCS) - introduction, DCS architecture, control modes.

Introduction to OPC DA/UA , HART, fieldbus, and PROFIBUS.

Text Books

1. Mikell P Groover, *Automation, Production systems and Computer integrated Manufacturing*, Pearson Education, 4th ed., 2016.
2. A.K. Sawhney, *A Course in Electrical Measurements, Electronic Measurements and Instrumentation*, Dhanpat Rai and Co., 2015.
3. Curtis D Johnson, *Process Control Instrumentation Technology*, Pearson, 8th ed., 2005.
4. William Bolton, *Programmable Logic Controllers*, Elsevier India Pvt Ltd, New Delhi, 6th ed., 2015
5. Stuart A. Boyer, *SCADA: Supervisory Control and Data Acquisition*, International Society of Automation, 4th ed., 2010.

Reference Books

1. G.K.McMillan, *Process/Industrial Instrument and control and hand book*, McGraw Hill Education, New York, 5th ed., 1999.
2. Michael P. Lucas, *Distributed Control system*, Van Nostrand Reinhold Company, New York, 1986.
3. Patranabis, D, *Principles of Industrial Instrumentation*, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 3rd ed., 2010.
4. Robert B. Northrop, *Introduction to instrumentation and measurements*, CRC, Taylor and Francis, 3rd ed., 2018.
5. DVS. Murty, *Transducers and Instrumentation*, PHI Learning Pvt Ltd, New Delhi, 2nd ed., 2013.
6. Doebelin E.O, *Measurement Systems: Application and Design*, McGraw Hill, Newyork, 5th ed., 2004.
7. Sunit Kumar Sen, *Fieldbus and Networking in Process Automation*, CRC Press, 1st ed., 2014.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Automation and Industrial Control Systems	8
1.1	Introduction to automation-definition of automation - reasons for automating – types of automated manufacturing systems	1
1.2	Automation principles and strategies -basic elements of automated system	1
1.3	Advanced automation functions-levels of automation	1
1.4	Industrial control systems- process and discrete manufacturing industries-continuous and discrete control systems	2
1.5	Overview of computer process control- control requirements-capabilities of computer control	1
1.6	Forms of computer process control -DDC, CNC, PLC, SCADA, DCS	2
	Module 2: Sensors	6
2.1	Configuration of the process control system	1
2.2	Thermal sensors-RTDs, thermistors, thermocouples	1
2.3	Mechanical sensors-LVDT, load cell, metal strain gauges, piezoelectric accelerometer, bourdon tube, solid state pressure sensors	1
2.4	Optical sensors-photovoltaic detectors, photo emissive detector-hall effect sensor	1
2.5	Micro Electromechanical system (MEMS), advantages and applications, MEMS micro sensors and actuators, MEMS accelerometers	2
	Module 3: Actuators and Control Elements	6
3.1	Final control operation- elements of final control operation-signal conversion	1
3.2	Actuators- electric actuators-DC motors, synchronous motors, induction motors, stepper motors, rotary to linear motion conversion, linear motors	1
3.3	Solenoid-electromechanical relay - hydraulic and pneumatic actuators - piezoelectric actuator	1
3.4	Control elements-mechanical, electrical, fluid valves	1
	Virtual Instrumentation System	
3.5	Architecture of virtual instruments – virtual instruments and traditional instruments – concepts of graphical programming	2
	Module 4: Programmable Logic Controllers (PLC)	8
4.1	Programmable logic controllers-introduction to PLC - hardware details-internal architecture	2

4.2	PLC input and output devices-Series and Parallel communications-protocols	2
4.3	Introduction to IEC 61131 standard- ladder programming-realization of logic functions, concept of latching	2
4.4	Introduction to timer/counters, exercises based on timers and counters	2
	Module 5: SCADA and DCS Systems	8
5.1	SCADA: Introduction, SCADA Architecture, common system components	2
5.2	Supervision and Control, HMI, RTU and Supervisory stations	1
5.3	Protocols-IEC 60870-5-101 and IEC 60870-5-104	1
5.4	DCS: Introduction, DCS architecture	1
5.5	Control modes	1
5.6	Introduction to OPC DA/UA, HART, Fieldbus and PROFIBUS	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the need for automation.
2. Describe various levels of automation.
3. Differentiate between continuous and discrete control in process industries.

Course Outcome 2 (CO 2)

1. Explain the working principle of RTDs and Thermocouples.
2. Explain the working of LVDT and Piezoelectric accelerometer.
3. Describe the principle of operation of various optical sensors.

Course Outcome 3 (CO 3)

1. Illustrate the elements of final control operation.
2. Describe the working of actuators used in process control.
3. Explain architecture of virtual instruments.

Course Outcome 4 (CO 4)

1. Explain internal architecture of PLC.
2. Differentiate between series and parallel communication.
3. Implement logic gates and simple operations using PLC.

Course Outcome 5 (CO 5)

1. Explain the architecture and protocols involved in SCADA systems.
2. Describe the architecture of Distributed Control System.
3. Differentiate between HART, Fieldbus and PROFIBUS.

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: : B24EE3G15

Course Name: : INDUSTRIAL AUTOMATION

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. List out the needs for automation.
2. What are the basic elements of an automated system?
3. Explain the operation of hall effect sensor.
4. List the advantages and disadvantages of MEMS micro sensors.
5. Explain the elements of the final control operation.
6. Differentiate between virtual instruments and traditional instruments.
7. Implement basic gate operations using PLC ladder logic.
8. Write a PLC program to obtain a delay of 10ms for process control.
9. List the main components associated with SCADA systems.
10. Compare Profibus and Field-bus used in data transmission.

PART B

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

11. (a) Define an automated system. Explain various types of automated manufacturing systems. (8 marks)
- (b) Describe various automation principles and strategies. (6 marks)

OR

12. (a) Explain the levels of automation in process industries and discrete manufacturing industries. (7 marks)
- (b) Explain the various forms of computer process control. (7 marks)
13. (a) Describe the steps involved in bulk micromachining fabrication of MEMS. (6 marks)
- (b) Explain working of any four types of MEMS actuators along with their application. (8 marks)

OR

14. (a) Differentiate between photovoltaic detectors and photo-emissive detector. (6 marks)
- (b) With neat diagram explain the working of a LVDT transducer, give any one application of LVDT. (8 marks)
15. Explain different types of actuators used in process control. (14 marks)

OR

16. (a) Explain the architecture of Virtual instrumentation system. (10 marks)
- (b) Describe the concept of graphical programming. (4 marks)
17. Design a ladder program to switch on a pump for 100 s. It is then to be switched off, and a heater switched on for 50 s. Then the heater is switched off, and another pump is used to empty the water. (14 marks)

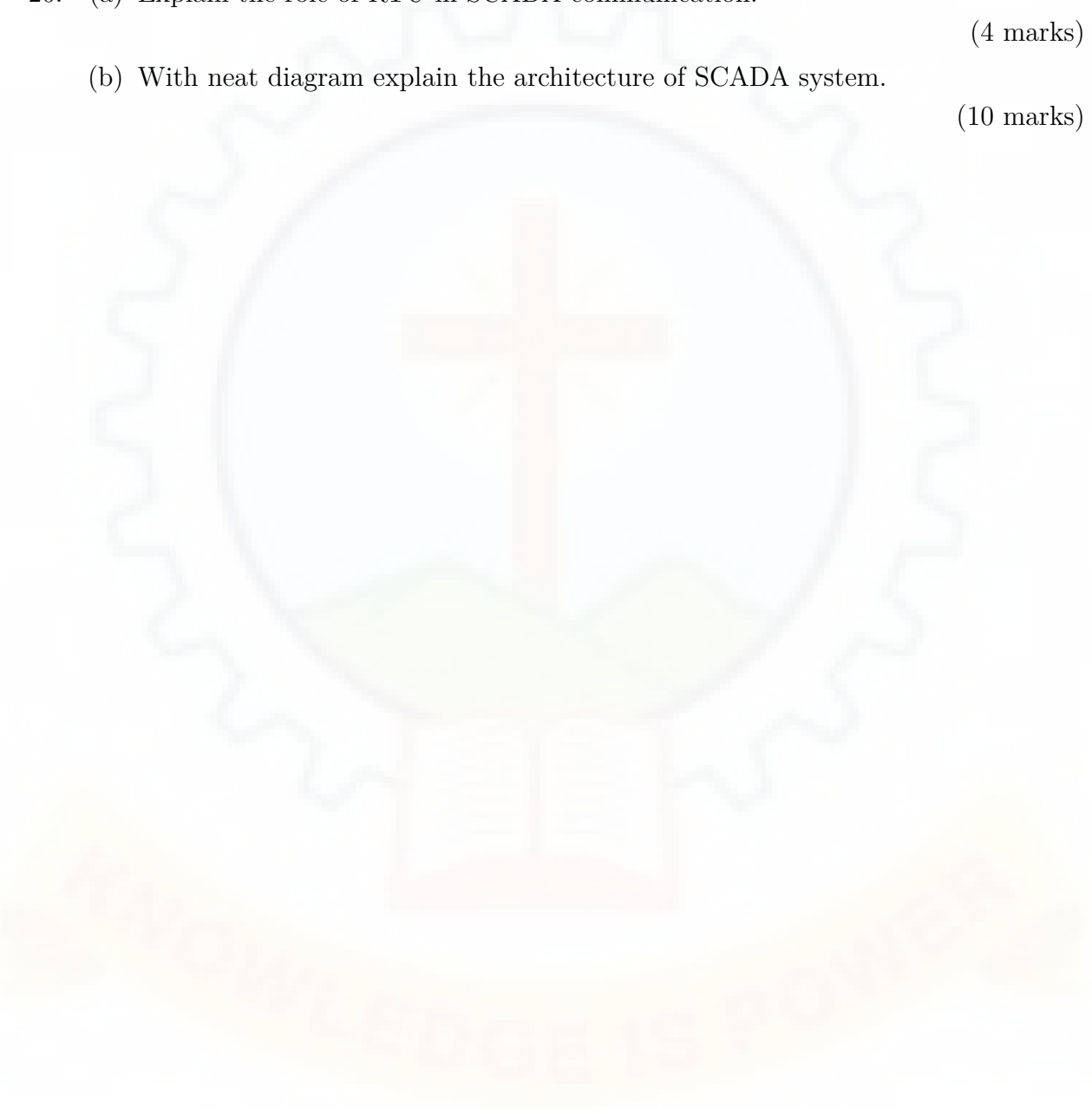
OR

18. Draw a block diagram of a PLC showing the main functional items and how buses link them, explaining the functions of each block. (14 marks)

19. (a) With neat diagram explain the architecture of distributed control system. (7 marks)
- (b) Describe in detail the protocols for SCADA communication. (7 marks)

OR

20. (a) Explain the role of RTU in SCADA communication. (4 marks)
- (b) With neat diagram explain the architecture of SCADA system. (10 marks)



B24EE3G16	ELECTRIC VEHICLE TECHNOLOGY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course is designed to impart comprehensive knowledge and foundational concepts related to electric vehicles (EVs). It provides detailed information on various electric propulsion systems and battery management technologies used in EVs. Additionally, the course focuses on communication protocols and the different charging systems employed in electric vehicles.

Prerequisites

Nil

Course Outcomes

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

CO 1	Illustrate and explain the configurations and architectures of electric, hybrid electric, and plug-in hybrid electric vehicles (EV, HEV, and PHEV), and realize the fundamentals of power-component sizing. (Cognitive Knowledge Level: Understand)
CO 2	Identify and explain the electric drive components used in electric vehicle propulsion systems and their functional roles. (Cognitive Knowledge Level: Understand)
CO 3	Illustrate and explain energy storage systems and battery fundamentals, and identify the traction battery types used in electric vehicles. (Cognitive Knowledge Level: Understand)
CO 4	Apply vehicle controllers and communication systems in electric vehicles using AUTOSAR and CAN-based architecture. (Cognitive Knowledge Level: Apply)
CO 5	Identify and explain vehicle-grid interface frameworks (G2V, V2G, V2V, and V2H) and their role in integrating electric vehicles into microgrid systems. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	40	20	20
Understand	60	60	60
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/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 (7 hours)

Introduction to Electric Vehicles

Need for electric vehicle, configuration of EVs, performance of EVs - traction motor characteristics. Vehicle architecture - electric vehicles, hybrid electric vehicles, plug-in hybrid electric vehicles, power component sizing - electric vehicle, vehicle simulation model.

MODULE 2 (8 hours)

Electric Propulsion Systems

Electric drive components, DC motor drives - chopper controlled, two-quadrant, four-quadrant operation, induction motor drives - constant volt/hertz control, power electronic control, permanent magnet BLDC motor drives - control of BLDC motor drives, SRM drives - basic structure, design, regenerative braking.

MODULE 3 (8 hours)

Battery Energy Storage

Introduction to energy storage, battery parameter - battery capacity, open circuit voltage, terminal voltage, practical capacity, discharge rate, state of charge, depth of discharge, specific energy, battery power, battery modelling, traction batteries - types, battery management system.

MODULE 4 (7 hours)

Vehicle Controllers and Communication

Vehicle controllers - microcontroller types, components, controller software development - AUTOSAR, software development tools, controller implementation, motor controller. Vehicle communications - OSI seven-layer model, controller area network - CAN transfer protocol, transfer layer, message frames.

MODULE 5 (6 hours)

Electric Vehicles and Power Grid

Vehicle grid interface -G2V, V2G, V2V, and V2H frameworks, electric vehicle charging - DC fast charger, 480 V fast charger, MV fast charger, electric vehicle charging station, electric vehicles in microgrids.

Text Books

1. Iqbal Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2003.
2. M.Ehsani, Y.Gao, A.Emadi, *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles*.
3. K. Sundareswaran R. A, *Elementary Concepts of Power Electronic Drives*, CRC Press, Taylor & Francis Group.

Reference Books

1. James Larminie, John Lowry, *Electric Vehicle Technology Explained*, 2nd ed., Wiley.
2. Per Enge, Nick Enge, Stephen Zoepf, *Electric Vehicle Engineering*, 1st ed., McGraw Hill, 2021.
3. Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen, *Electric Vehicles Modern Technologies and Trends*, Springer, 2021.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Electric Vehicles	7
1.1	Need for electric vehicle, configuration of EVs	1
1.2	Performance of EVs - traction motor characteristics	1
1.3	Vehicle architecture - electric vehicles	1
1.4	Hybrid electric vehicles, plug-in hybrid electric vehicles	1
1.5	Plug-in hybrid electric vehicle	1
1.6	Power component sizing - electric vehicle	1
1.7	Vehicle simulation model	1
	Module 2: Electric Propulsion Systems	8
2.1	Electric drive components, DC motor drive	1
2.2	Chopper controlled, two-quadrant, four-quadrant operation	1
2.3	Induction motor drives	1
2.4	Constant volt/hertz control, power electronic control	1
2.5	Permanent magnet BLDC motor drives	1
2.6	Control of BLDC motor drives	1
2.7	SRM drives - basic structure, design	1
2.8	Regenerative braking	1
	Module 3: Battery Energy Storage	8
3.1	Introduction to energy storage	1
3.2	Battery parameter - battery capacity, open circuit voltage	1
3.3	Terminal voltage, practical capacity	1

3.4	Discharge rate, state of charge	1
3.5	Depth of discharge, specific energy, battery power	1
3.6	Battery modelling	1
3.7	Traction batteries - types	1
3.8	Battery management system	1
	Module 4: Vehicle Controllers and Communication	7
4.1	Vehicle controllers - microcontroller types	1
4.2	Components, controller software development	1
4.3	AUTOSAR, software development tools	1
4.4	Controller implementation, motor controller	1
4.5	Vehicle communications - OSI seven-layer mode	1
4.6	Controller area network - CAN transfer protocol	1
4.7	Transfer layer, message frames	1
	Module 5: Electric Vehicles and Power Grid	6
5.1	Vehicle grid interface -G2V, V2G	1
5.2	V2V, and V2H frameworks	1
5.3	Electric vehicle charging - DC fast charger	1
5.4	480 V fast charger, MV fast charger	1
5.5	Electric vehicle charging station	1
5.6	Electric vehicles in microgrids.	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain vehicle architecture.
2. Classify types of electric vehicles.
3. Discuss vehicle simulation model.

Course Outcome 2 (CO 2)

1. Explain DC motor drives.
2. Describe regenerative braking system.
3. Discuss the control operation of BLDC motor drives.

Course Outcome 3 (CO 3)

1. Explain battery management system.
2. Classify various types of traction batteries.

3. Discuss the battery parameters associated with EVs.

Course Outcome 4 (CO 4)

1. Identify various microcontroller types used in EVs.
2. Explain CAN transfer protocol.
3. Explain the role of AUTOSAR.

Course Outcome 5 (CO 5)

1. Classify various types of vehicle grid interface.
2. Explain the need of 480 V charger.
3. Describe the components of electric charging stations.

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: : B24EE3G16

Course Name: : ELECTRIC VEHICLE TECHNOLOGY

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. List the reasons that highlight the need for electric vehicles.
2. Illustrate the block diagram of the vehicle simulation model.
3. Explain the block diagram of an electric drive.
4. Explain the importance of regenerative braking for EVs.
5. Explain the term SOC for battery systems.
6. Explain the need of battery management system for EVs.
7. List out the components used in the vehicle controller for electric vehicles.
8. Explain the significance of CAN used in electric vehicles.
9. Classify the various types of charging units for electric vehicles.
10. Explain the significance of electric vehicles on micro grids.

PART B

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

11. Explain in detail the various configurations of electric vehicles and discuss the characteristics of traction motors.

(14 marks)

OR

12. Explain in detail the vehicle architecture of electric vehicles.

(14 marks)

13. Discuss in detail DC drive fed electric propulsion system for EVs.

(14 marks)

OR

14. Explain in detail the control and operation of BLDC motor drives used in electric vehicles.

(14 marks)

15. Discuss the various battery parameters and its importance for electric vehicle applications.

(14 marks)

OR

16. Explain in detail about the operation and performance of various types of traction batteries.

(14 marks)

17. Explain in detail about vehicle controllers and their types.

(14 marks)

OR

18. Explain in detail about the communication system adopted in electric vehicles.

(14 marks)

19. Explain in detail about electric vehicle charging stations and classify the various types of vehicle-grid interfaces.

(14 marks)

OR

20. Explain in detail about electric vehicle charging systems and also explain types of chargers used in electric vehicles.

(14 marks)

A large, faint watermark logo is centered on the page. It features a gear-like outer border. Inside the gear is a circle containing a cross. Below the cross is a stylized green mountain range. At the base of the mountains is an open book. A yellow banner curves around the bottom of the gear, containing the text 'KNOWLEDGE IS POWER' in capital letters.

MINOR

B24EEM61	INDUSTRIAL INSTRUMENTA- TION AND AUTOMATION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

The aim of this course is to provide a solid foundation in process control and instrumentation, emphasizing the principles, components, and technologies that enable modern industrial automation. The course covers mechanical and electrical transducers, actuators and control elements, virtual instrumentation, PLC programming, and supervisory systems such as SCADA and DCS, along with communication protocols. Upon completion, students will be able to comprehend, analyze, and apply fundamental automation and control concepts in industrial environments.

Prerequisites

NIL

Course Outcomes

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

CO 1	Explain the functioning of process control and various Mechanical Transducers. (Cognitive knowledge level: Understand)
CO 2	Select a suitable Transducer for the given application based on the evaluation of the constraints. (Cognitive knowledge level: Understand)
CO 3	Select a suitable actuator system for the given application based on the evaluation of the constraints and to develop automation strategy for an automation plant. (Cognitive knowledge level: Apply)
CO 4	Develop the logic for the process control applications using PLC programming. (Cognitive knowledge level: Apply)
CO 5	Describe the fundamental concepts of DCS and SCADA systems and Identify communication protocol for an industrial process. (Cognitive knowledge level: Understand)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	40	20	20
Understand	60	40	40
Apply		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)

Introduction to Process Control

Introduction to process control – principle, identification of elements, and block diagram of the process control loop, analog and digital processing, process control drawings, sensor time response.

Mechanical Transducers

Transducers - classification, static and dynamic characteristics of transducers, choice of the transducer. Mechanical transducers, temperature measurement - bimetallic element, fluid expansion systems, pressure measurement - bourdon tube elements, force measurement - column type load cell, torque measurement - torsion bar, flat spiral spring, seismic displacement transducer, gyroscope.

MODULE 2 (11 hours)

Electrical Transducers

Passive electrical transducers, resistive transducers - resistance thermometers, resistive strain transducers-bonded and unbonded, strain gauge accelerometers, strain gauge torque transducer, resistive magnetic flux transducers.

Inductive transducers - inductive thickness transducers, linear variable differential transformer. Capacitive transducers - capacitive thickness transducers, capacitive displacement transducers -proximity transducer, variable area capacitive transducer.

Active electrical transducers - principle of operation, construction and applications - thermoelectric transducers, piezo-electric transducers, hall-effect transducer, electromechanical transducers -tachometers and electrodynamic vibration transducers, photo-voltaic transducer, photo-emissive transducer, digital transducer - optical encoder and digital tachometers.

MODULE 3 (8 hours)

Actuators and Control Elements

Final control operation- elements of final control operation, signal conversion, actuators - electrical, pneumatic, and hydraulic, control elements - mechanical, electrical, fluid valves.

Process Control Instrumentation and Virtual Instrumentation System

Process control instrumentation - pharmaceutical, aerospace, nuclear power and bioprocess industries. Virtual instrumentation system - architecture of virtual instruments, virtual instruments and traditional instruments, concepts of graphical programming.

MODULE 4 (10 hours)

Programmable Logic Controllers (PLC)

Programmable logic controllers - introduction to PLC, hardware details, internal architecture, PLC input and output devices. Input/output processing - input units and output units, series and parallel communications - protocols. Introduction to IEC 61131 standard - ladder programming, realization of logic functions, concept of latching, introduction to timer/counters, exercises based on timers and counters.

MODULE 5 (7 hours)

SCADA and DCS Systems

SCADA (Supervisory Control and Data Acquisition) - introduction, SCADA architecture, common system components, supervision and control, HMI, RTU and supervisory stations, protocol - IEC 60870-5-104.

DCS (Distributed Control System) - introduction, DCS architecture, control modes. Introduction to OPC DA/UA, HART, Fieldbus and PROFIBUS.

Text Books

1. Curtis D. Johnson, *Process Control Instrumentation Technology*, Pearson, 8th ed., 2005.
2. D. V. S. Murty, *Transducers and Instrumentation*, PHI Learning Pvt Ltd, 2nd ed., 2013.
3. A. K. Sawhney, *A Course in Electrical Measurements, Electronic Measurements and Instrumentation*, Dhanpat Rai and Co., 2015.
4. Jovitha Jerome., *Virtual instrumentation using LabVIEW*, PHI Learning Pvt Ltd, 2010.
5. William Bolton, *Programmable Logic Controllers*, Elsevier India Pvt Ltd, 6th ed., 2015.

Reference Books

1. G. K. McMillan, *Process/Industrial Instrument and control and hand book*, McGraw Hill Education, 5th ed., 1999.
2. Doebelin E. O, *Measurement Systems: Application and Design*, McGraw Hill, 5th ed., 2004.
3. Patranabis D., *Principles of Industrial Instrumentation*, Tata McGraw Hill Publishing Co. Ltd., 3rd ed., 2010.

4. Robert B. Northrop, *Introduction to instrumentation and measurements*, CRC, Taylor and Francis, 3rd ed., 2018.
5. Stuart A. Boyer, *SCADA: Supervisory Control and Data Acquisition*, International Society of Automation, 4th ed., 2010.
6. Michael P. Lucas, *Distributed Control system*, Van Nostrand Reinhold Company, 1986.
7. Sunit Kumar Sen, *Fieldbus and Networking in Process Automation*, CRC Press, 1st ed., 2014.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Introduction to Process Control	9
1.1	Introduction to process control – principle, identification of elements, block diagram of the process control loop	1
1.2	Analog and digital processing	1
1.3	Process control drawings-sensor time response	1
1.4	Transducers-classification- choice of the transducer	1
1.5	Static and dynamic characteristics of transducers	2
	Mechanical Transducers	
1.6	Temperature measurement-bimetallic element, fluid expansion systems, pressure measurement-bourdon tube elements	1
1.7	Force measurement-column type load cell, torque measurement-torsion bar, flat spiral spring	1
1.8	Seismic displacement transducer, gyroscope	1
	Module 2: Electrical Transducers	11
2.1	Passive electrical transducers-resistive transducers-resistance thermometers, resistive strain transducers-bonded and unbonded.	1
2.2	Strain gauge accelerometers, strain gauge torque transducer, resistive magnetic flux transducers	1
2.3	Inductive transducers- inductive thickness transducers, linear variable differential transformer	1
2.4	Capacitive transducers- capacitive thickness transducers, capacitive displacement transducers-proximity transducer, Variable area capacitive transducer	1
2.5	Active electrical transducers: principle of operation, construction and applications of thermoelectric transducers	1
2.6	Principle of operation, construction and applications of Piezo-electric transducers	2

2.7	Principle of operation, construction and applications of hall effect transducer, electromechanical transducers-tachometers, electrodynamic vibration transducers	2
2.8	Principle of operation, construction and applications of Photo-voltaic transducer, photo emissive transducer	1
2.9	Principle of operation, construction and applications of digital transducer-optical encoder and digital tachometers	1
	Module 3: Actuators and Control Elements	8
3.1	Final control operation- elements of final control operation-signal conversion	2
3.2	Actuators- electrical, pneumatic, hydraulic	2
3.3	Control elements-mechanical, electrical, fluid valves	1
	Process Control Instrumentation and Virtual Instrumentation System	
3.4	Process control instrumentation for following industries – pharmaceutical, aerospace, nuclear power and bioprocess industries	1
3.5	Virtual instrumentation system: architecture of virtual instruments – virtual instruments and traditional instruments – concepts of graphical programming	2
	Module 4: Programmable Logic Controllers (PLC)	10
4.1	Programmable logic controllers-introduction to PLC – hardware details -internal architecture	2
4.2	PLC input and output devices	2
4.3	Input/Output processing-input units, output units	1
4.4	Series and parallel communications-protocols	1
4.5	Introduction to IEC 61131 standard- ladder programming-realization of logic functions, concept of latching	2
4.6	Introduction to timer/counters, exercises based on timers and counters	2
	Module 5: SCADA and DCS Systems	7
5.1	SCADA: Introduction, SCADA architecture, common system components	1
5.2	Supervision and Control, HMI, RTU and supervisory stations, protocol-IEC 60870-5-104	2
5.3	DCS: Introduction, DCS architecture, control modes	2
5.4	Introduction to OPC DA/UA, HART, Fieldbus and PROFIBUS	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the block diagram of a process control loop.
2. Explain different characteristics of transducers.
3. Selection of mechanical transducers for various applications.

Course Outcome 2 (CO 2)

1. Explain the working principle of strain gauge torque transducer.
2. Compare and contrast the working of inductive and capacitive thickness transducers.
3. Describe the construction and application of hall effect transducer.

Course Outcome 3 (CO 3)

1. Explain the elements of final control operation.
2. Describe process control instrumentation systems in pharmaceutical sector.
3. Explain architecture of virtual instruments.

Course Outcome 4 (CO 4)

1. Explain the internal architecture of PLC.
2. Differentiate between series and parallel communication.
3. Implement logic gates and simple operations using PLC.

Course Outcome 5 (CO 5)

1. Explain the architecture and protocols involved in SCADA systems.
2. Describe the architecture of Distributed Control System.
3. Differentiate between HART, Field-bus and PROFIBUS.

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg.No.:

Name:

**MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),
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SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2027

Course Code: : B24EEM61

Course Name: : INDUSTRIAL INSTRUMENTATION AND AUTOMATION

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Identify the factors to be considered while selecting a transducer for a specific application.
2. Explain the construction and operation of a gyroscope.
3. Describe the operation of inductive thickness transducers.
4. Differentiate between passive and active electrical transducers.
5. Explain the elements of the final control operation.
6. Differentiate between virtual instruments and traditional instruments.
7. Implement basic gate operations using PLC ladder logic.
8. Write a PLC program to obtain a delay of 10ms for process control.
9. List the main components associated with SCADA systems.
10. Compare Profibus and Field-bus used in data transmission.

PART B

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

11. (a) With the help of a diagram explain the process control loop. (8 marks)
- (b) Explain second order time response of sensor. (6 marks)

OR

12. (a) Explain the construction and operation of bourdon tube elements for pressure measurement. (6 marks)
- (b) Illustrate static and dynamic characteristics of transducers. (8 marks)
13. With the help of neat diagram explain the principle of operation, construction and application of, i) Piezo-electric transducers ii) Hall-effect transducer iii) Photo-voltaic transducer iv) Digital transducer. (14 marks)

OR

14. (a) Explain the construction and working principle of Capacitive differential pressure measurement. (7 marks)
- (b) Explain the construction and working principle of Linear Variable Differential Transformer. (7 marks)
15. Explain different types of actuators used in process control. (14 marks)

OR

16. (a) Explain the architecture of Virtual instrumentation system. (10 marks)
- (b) Describe the concept of graphical programming. (4 marks)
17. Design a ladder program to switch on a pump for 100 s. It is then to be switched off, and a heater switched on for 50 s. Then the heater is switched off, and another pump is used to empty the water. (14 marks)

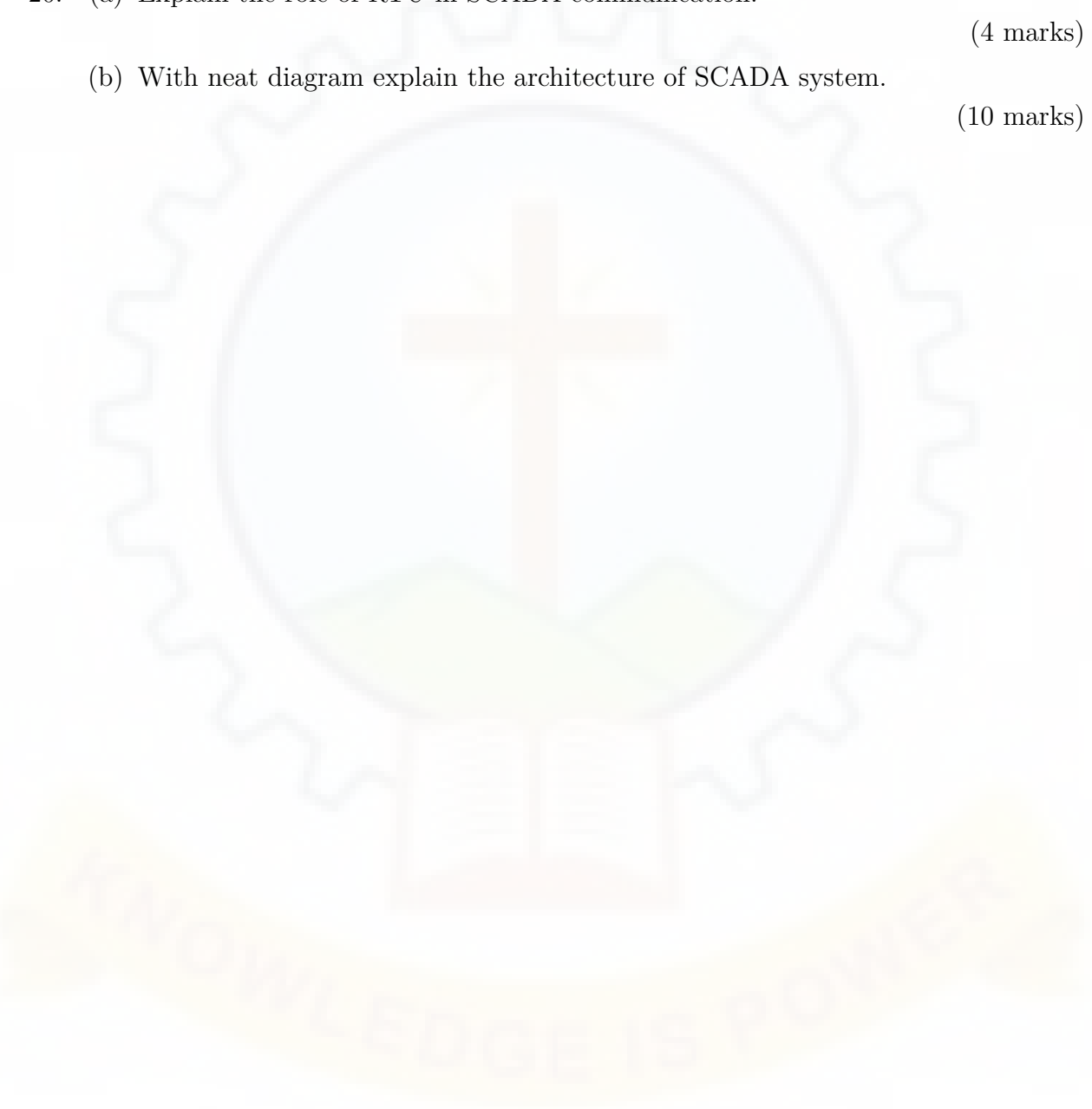
OR

18. Draw a block diagram of a PLC showing the main functional items and how buses link them, explaining the functions of each block. (14 marks)

19. (a) With neat diagram explain the architecture of distributed control system. (7 marks)
- (b) Describe in detail the protocol for SCADA communication. (7 marks)

OR

20. (a) Explain the role of RTU in SCADA communication. (4 marks)
- (b) With neat diagram explain the architecture of SCADA system. (10 marks)



B24EEM62	POWER ELECTRONIC DRIVES	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course aims to provide a foundational understanding of power electronic drive systems and their role in controlling and optimizing the performance of electric machines. It covers the dynamics of electric drives, rectifier- and chopper-controlled DC motor drives, induction motor speed-control techniques, and applications of drive technology in electric vehicles and smart infrastructure. Upon completion, students will be able to understand, analyze, and apply appropriate drive configurations to ensure efficient, reliable, and sustainable operation of modern electromechanical systems.

Prerequisites

Fundamentals of Electrical Machines, Solid State Power Conversion

Course Outcomes

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

CO 1	Understand the fundamental principles and dynamics of electric drives. (Cognitive Knowledge Level: Understand)
CO 2	Apply controlled rectifier configurations for the speed control of separately excited DC motors under different operating modes. (Cognitive Knowledge Level: Apply)
CO 3	Analyze the operation of two-quadrant and four-quadrant chopper-fed DC motor drives and interpret their motoring and regenerative braking behavior. (Cognitive Knowledge Level: Apply)
CO 4	Apply various speed-control techniques to three-phase induction motor drives. (Cognitive Knowledge Level: Apply)
CO 5	Assess the role of electric drives in electric vehicle applications. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2							1	1	1
CO 2	3	3	2		3				1	1	2
CO 3	3	3	2		3				1	1	2
CO 4	3	3	2		3				1	1	2
CO 5	3	3	2			2	1	1	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/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 (8 hours)

Electric Drives

Electric drives - block diagram, advantages of electric drives, dynamics of motor load system, fundamental torque equations, classification of load torque, four quadrant operation of drives, steady state stability.

MODULE 2 (9 hours)

Rectifier Control of DC Drives

Separately excited DC motor drives using controlled rectifiers - single-phase fully controlled rectifier fed drives - continuous mode of operation, critical speed, single-phase semi-converter fed drives - continuous mode of operation, dual converter control of DC motor - circulating current mode, and non-circulating current mode.

Use simulation software like MATLAB/Simulink to simulate converter fed DC motor drives. (Assignment/ Tutorial only)

MODULE 3 (8 hours)

Chopper Control of DC Drives

Chopper control of DC drives - two-quadrant and four-quadrant chopper drives, motoring and regenerative braking, chopper-fed DC series motor drive, closed-loop speed control for separately excited DC motor.

Use simulation software like MATLAB/Simulink to simulate chopper fed DC motor drives. (Assignment/ Tutorial only)

MODULE 4 (10 hours)

Three-Phase Induction Motor Drives

Three-phase induction motor drives - stator voltage control, stator frequency control, v/f control - below and above base speed, static rotor resistance speed control employing chopper, static slip power recovery speed control, scheme for speed control below synchronous speed.

Use simulation software like MATLAB/Simulink to simulate induction motor drives. (Assignment/ Tutorial only)

MODULE 5 (10 hours)

Application of Electric Drives in Electric Vehicles

Role of electric drives in propulsion, braking, and auxiliaries (Concept only), drive performance expectations - torque, speed, efficiency, common motor-drive combinations used in EVs - BLDC, PMSM, IM with inverters, regenerative braking using electric drives, power converter integration with drives in EVs, role of drive systems in smart EV infrastructure - charging station planning, grid interaction, sustainability and lifecycle aspects related to drive systems.

Text Books

1. Muhammad H. Rashid, *Power Electronics: Circuits, Devices and Applications*, Pearson, 4th ed., 2014.
2. Bimal K. Bose , *Power Electronics and Motor Drives: Advances and Trends*, Elsevier, 2nd ed., 2020.
3. Vinod Kumar, Ranjan K. Behera, Dheeraj Joshi & Ramesh Bansal , *Power Electronics, Drives, and Advanced Applications*, CRC Press, 1st ed., 2020.
4. Andrzej M. Trzynadlowski, *Introduction to Modern Power Electronics*, Wiley, 3rd ed., 2015.

Reference Books

1. Ned Mohan, Tore M. Undeland & William P. Robbins, *Power Electronics: Converters, Applications and Design*, Wiley, 4th ed., 2023.
2. Robert W. Erickson & Dragan Maksimović *Fundamentals of Power Electronics*, Springer, 3rd ed., 2020.
3. Muhammad H. Rashid , *Power Electronics Handbook*, Academic Press, 5th ed., 2022.
4. G. K Dubey , *Power Electronics Handbook*, Narosa Publishing House, 2nd ed., 2001.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Introduction to Electric Drives	8
1.1	Electric drives - block diagram, advantages of electric drives	2
1.2	Dynamics of motor load system	1
1.3	Fundamental torque equations, classification of load torque	1
1.4	Four quadrant operation of drives	2
1.5	Steady state stability	2
	Module 2: Rectifier control of DC Drives	9
2.1	Separately excited DC motor drives using controlled rectifiers	2
2.2	Single-phase fully controlled rectifier fed drives - continuous mode of operation, critical speed	2
2.3	Single-phase semi-converter fed drives - continuous mode of operation	2
2.4	Dual converter control of DC motor - circulating current mode	2
2.5	Dual converter control of DC motor -non- circulating current mode	1
	Module 3: Chopper control of DC Drives	8
3.1	Chopper control of DC drives - two-quadrant chopper drives	2
3.2	Four-quadrant chopper drives	2
3.3	Motoring and regenerative braking	2
3.4	Chopper-fed DC series motor drive, closed-loop speed control for separately excited DC motor	2
	Module 4: Induction Motor Drives	10
4.1	Three-phase induction motor drives - stator voltage control	2
4.2	Stator frequency control	2
4.3	V/f control - below and above base speed	2
4.4	Static rotor resistance speed control employing chopper	2
4.5	Static slip power recovery speed control, scheme for speed control below synchronous speed	2
	Module 5: Application of Electric Drives in Electric Vehicles	10
5.1	Role of electric drives in propulsion, braking, and auxiliaries (Concept only)	1
5.2	Drive performance expectations - torque, speed, efficiency	2
5.3	Common motor-drive combinations used in EVs - BLDC, PMSM, IM with inverters	2

5.4	Common motor-drive combinations used in EVs - BLDC, PMSM, IM with inverters	2
5.5	Charging station planning, grid interaction, sustainability and lifecycle aspects related to drive systems	1
5.6	Role of drive systems in smart EV infrastructure - charging station planning, grid interaction, sustainability and lifecycle aspects related to drive systems	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the fundamental torque equation of an electric drive system and describe the significance of each term involved.
2. Describe the operating characteristics of electric drives and illustrate their behavior under different load torque conditions.
3. Explain the dynamics of a motor-load system and discuss the factors influencing transient and steady-state response.

Course Outcome 2 (CO 2)

1. Apply a suitable single-phase controlled rectifier configuration to achieve speed control of a separately excited DC motor operating in continuous conduction mode.
2. Determine the armature voltage variation of a rectifier-fed DC motor for different firing angles and interpret its effect on motor speed.
3. Apply dual-converter control principles to explain forward and reverse speed control of a separately excited DC motor.

Course Outcome 3 (CO 3)

1. Analyze the operation of a two-quadrant chopper-fed DC motor drive and interpret its motoring and regenerative braking modes.
2. Analyze the effect of square-wave operation on inverter output waveform quality and system efficiency.
3. Analyze the switching sequences of a four-quadrant chopper and explain how bidirectional power flow is achieved.

4. Interpret the torque–speed characteristics of chopper-controlled DC motor drives during regenerative braking.

Course Outcome 4 (CO 4)

1. Apply stator voltage control to regulate the speed of a three-phase induction motor and explain its limitations.
2. Apply V/f control principles to achieve constant torque operation in induction motor drives below base speed.
3. Apply suitable speed-control techniques to an induction motor drive operating below synchronous speed and justify the choice.

Course Outcome 5 (CO 5)

1. Explain the role of electric drives in EV propulsion and braking systems with reference to energy efficiency.
2. Describe the function of electric drives in auxiliary systems of electric vehicles.

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: : B24EEM62

Course Name: : POWER ELECTRONIC DRIVES

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the advantages of electric drives over mechanical drive systems in industrial applications.
2. Describe the block diagram of electric drives.
3. Compare circulating and non-circulating current modes in dual converter control of DC motors.
4. Describe how a two-quadrant chopper achieves both motoring and braking in a DC motor drive.
5. Draw the block diagram closed-loop speed control in a separately excited DC motor using a chopper.
6. What is stator voltage control in three-phase induction motor drives.
7. Explain V/f control in Induction Motor Drives.
8. Analyze how motor–drive combinations such as BLDC and PMSM influence performance requirements like torque and efficiency in EV propulsion.
9. Describe the role of electric drives in regenerative braking used in electric vehicles.
10. Analyze how motor–drive combinations such as BLDC and PMSM influence performance requirements like torque and efficiency in EV propulsion.

PART B

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

11. Derive the fundamental torque equation of an electric drive system and explain the significance of each term. Also list out the different load torques. (14 marks)

OR

12. (a) Discuss the concept of four-quadrant operation of an electric drive with suitable torque-speed characteristics. (7 marks)
- (b) Examine the conditions for steady-state stability in electric drives and explain their relevance in industrial applications. (7 marks)
13. (a) Explain the operation of a single-phase semi-converter feeding a separately excited DC motor. Support your answer with armature voltage waveforms. (7 marks)
- (b) Discuss the concept of critical speed in rectifier-fed DC motor drives and derive the expression for critical speed. (7 marks)

OR

14. (a) With waveforms, describe the operation of a fully controlled bridge rectifier supplying a DC motor and explain how firing angle affects armature voltage. (7 marks)
- (b) Explain with waveforms the operation of a three-phase half-wave controlled rectifier supplying an R-load. (7 marks)
15. (a) Explain the operation of a single-phase full-bridge inverter using unipolar switching. Provide appropriate waveforms. (7 marks)
- (b) With diagrams explain 180° conduction modes of a three-phase inverter. (7 marks)

OR

16. (a) Discuss single pulse and multiple pulse modulation techniques used in inverters. Include relevant waveform sketches. (7 marks)
- (b) Evaluate the advantages of sinusoidal PWM over other PWM strategies in terms of harmonic reduction and voltage control. (7 marks)
17. (a) With neat diagrams, explain the V/f control method for induction motor drives and derive the relationship between torque and flux. (7 marks)

- (b) Discuss the static slip power recovery scheme and explain how it facilitates speed control below synchronous speed. (7 marks)

OR

18. Discuss the operation of a four-quadrant chopper and show how it enables bidirectional current and voltage flow.

(14 marks)

19. (a) Explain the drive performance requirements (torque, speed, efficiency) of electric vehicles with suitable characteristics. (7 marks)

- (b) Discuss the operation of regenerative braking in EVs and explain how electric drives enable energy recovery. (7 marks)

OR

20. (a) Evaluate the suitability of BLDC, PMSM, and induction motors for EV propulsion with respect to efficiency and torque-speed profile.

(7 marks)

- (b) Describe the functional role of power converter and drive integration in smart EV infrastructure, including grid interaction. (7 marks)

B24EEM63	POWER SYSTEM AUTOMATION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course aims the integration of SCADA in power system automation, provides the essential framework for remote monitoring, real-time control, rapid fault recovery, ensuring reliable and efficient energy delivery. Upon successful completion of this course, students will be able to analyze real-time power system data using SCADA for effective operation and automation.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the architecture, components and functionality of SCADA systems, analyze their functions. (Cognitive Knowledge Level: Understand)
CO 2	Analyze SCADA and smart grid communication systems. (Cognitive Knowledge Level: Apply)
CO 3	Analyze modern automation architectures using smart devices and integrated systems. (Cognitive Knowledge Level: Apply)
CO 4	Analyze Energy Management Systems (EMS) and Wide Area Monitoring Systems (WAMS) for smart power system operations. (Cognitive Knowledge Level: Apply)
CO 5	Analyse the functions of Distribution Management Systems (DMS), Distribution Automation (DA) subsystems and coordination with other systems. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	3	3							2
CO 2	3	3	3	3							2
CO 3	3	3	3	3							2
CO 4	3	3	3	3							1
CO 5	3	3	3	3							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/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 (10 hours)

Power System Automation and SCADA

Introduction to Supervisory Control and Data Acquisition (SCADA) systems - component, applications, SCADA in power systems - SCADA basic functions, SCADA application. functions-generation, transmission, distribution, advantages.

Building blocks of SCADA systems, Remote Terminal Unit (RTU) - communication subsystem, logic subsystem, termination subsystem, testing and human machine interface (HMI) subsystem, power supplies. Intelligent Electronic Devices (IED) - functional block diagram, hardware and software architecture.

MODULE 2 (9 hours)

SCADA Communication

SCADA communication topologies, SCADA data communication techniques, data communication, SCADA communication protocol architecture, SCADA and smart grid protocols, media for SCADA and smart grid communication, unguided media, security for SCADA and smart grid communication, challenges for SCADA and smart grid communication.

MODULE 3 (8 hours)

Substation Automation

Conventional substations, new smart devices for substation automation, new integrated digital substation, technical issues, architectures, application functions, practical implementation.

MODULE 4 (9 hours)

Energy Management System (EMS)

Introduction, operating states, energy control centers, EMS framework, data acquisition and communication, generation operation and management, transmission operations and management, study mode simulations, post-event analysis and energy scheduling and accounting, dispatcher training simulator, smart transmission, EMS with WAMS, future trends in EMS and WAMS.

MODULE 5 (9 hours)

Distribution Automation and Distribution Management (DA/DMS) Systems

Subsystems in a distribution control center, DMS - framework, application functions coordination with other systems, customer automation functions, social media usage for improved reliability and customer satisfaction, future trends in DA and DMS.

Text Books

1. Mini S. Thomas, John D. McDonald, *Power System SCADA and Smart Grids*, CRC Press, 1st ed., 2015.
2. Er. Tanuj Kumar Bisht, *SCADA and Energy Management System*, S.K. Kataria Sons, 2nd ed., 2013.
3. John D. McDonald, *Electric Power Substations Engineering*, CRC Press, 3rd ed., 2011.
4. Stuart A. Boyer, *SCADA: Supervisory Control and Data Acquisition*, ISA, 4th ed., 2009.
5. Gordon Clarke, Deon Reynders, Edwin Wright, *Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems*, Newnes (Elsevier), 1st ed., 2004.

Reference Books

1. Abood S I, *Power System Protection And Relaying Computer Aided Design Using Scada Technology*, Atithi Books, 1st ed., 2024.
2. Praveen Arora, *SCADA and Power Systems*, Notion Press, 1st ed., 2021.
3. Rajesh Mehra, *PLCs & SCADA Theory and Practice*, Laxmi Publications Private Limited, 1st ed., 2019.
4. K S Manoj, *Industrial Automation with SCADA : Concepts, Communications and Security*, Notion Press, 1st ed., 2019.
5. Daniel Pinheiro Bernardon, Vinícius Jacques Garci, *Smart Operation for Power Distribution Systems: Concepts and Applications*, Springer International Publishing, 1st ed., 2018.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Power System Automation and SCADA	10
1.1	Introduction, Evolution of automation systems-Components of SCADA systems and SCADA applications	2
1.2	SCADA in power systems, SCADA basic functions and SCADA application functions	2
1.3	Building blocks of SCADA systems, Remote terminal unit (RTU)- communication subsystem, logic subsystem, termination subsystem	2
1.4	Testing and human machine interface (HMI) subsystem, Power supplies, advanced RTU functionalities	2
1.5	Intelligent Electronic Devices (IED)-functional block diagram, hardware and software architecture	2
	Module 2: SCADA Communication	9
2.1	Introduction, SCADA communication topologies and SCADA data communication techniques	1
2.2	SCADA data communication techniques, Data communication	1
2.3	SCADA communication protocol architecture	2
2.4	SCADA and smart grid protocols	2
2.5	Media for SCADA and smart grid communication, Guided media, Unguided (wireless) media	1
2.6	Security for SCADA and smart grid communication, Challenges for SCADA and smart grid communication	2
	Module 3: Substation Automation	8
3.1	Introduction, conventional substations	2
3.2	New smart devices for substation automation, new integrated digital substation	2
3.3	Technical issues, architectures	2
3.4	Application functions, practical implementation	2
	Module 4: Energy Management System (EMS)	9
4.1	Introduction, operating states, energy control centers, EMS framework	1
4.2	Data acquisition and communication, Generation operation and management	2
4.3	Transmission operations and management, study- mode simulations	1
4.4	Post - event analysis and energy scheduling and accounting	1
4.5	Dispatcher training simulator, smart transmission	3
4.6	EMS with WAMS, future trends in EMS and WAMS	1

	Module 5: Distribution Automation and Distribution Management (DA/DMS) Systems	9
5.1	Introduction to distribution automations, Subsystems in a distribution control center	3
5.2	DMS framework, DMS application functions DMS coordination with other systems	2
5.3	DMS coordination with other systems	1
5.4	Customer automation functions, Social media usage for improved reliability and customer satisfaction	2
5.5	Future trends in DA and DMS	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Define primary purpose of SCADA in power system automation.
2. Describe the role of the logic subsystem (processor/CPU) within the RTU architecture.
3. Define an Intelligent Electronic Device (IED).

Course Outcome 2 (CO 2)

1. List three common network topologies used in SCADA systems.
2. Identify two primary cybersecurity concerns specific to SCADA and smart grid communication systems.
3. Name three widely used communication protocols in modern SCADA and smart grid applications.

Course Outcome 3 (CO 3)

1. List three key limitations of conventional, hard-wired substations that leads towards automation.
2. Name three examples of "new smart devices" commonly used for modern substation automation.
3. List three important application functions managed by the Substation Automation System (SAS).

Course Outcome 4 (CO 4)

1. What is an Energy Management System (EMS).
2. List the four standard operating states of a power system.
3. What do you mean by WAMS.

Course Outcome 5 (CO 5)

1. Name the primary data sources that feed into the central DMS framework.
2. List three major subsystems typically found within a Distribution Control Center (DCC).
3. Mention one significant future trend expected in the evolution of DA and DMS.

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: : B24EEM63

Course Name: : POWER SYSTEM AUTOMATION

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the purpose of the Human-Machine Interface (HMI) subsystem from an operator's perspective.
2. Explain the three main hierarchical building blocks that constitute a complete SCADA system architecture.
3. List the standard layers found in the SCADA communication protocol architecture, referencing a simplified model.
4. Briefly explain the difference between serial and parallel data communication in SCADA devices.
5. Mention three significant technical issues or challenges encountered during the design and implementation of a modern digital substation.
6. Briefly define what constitutes a new integrated digital substation highlighting the core technological difference from conventional designs.
7. Name the major functional blocks within the typical EMS framework.
8. Briefly explain the purpose of study mode simulations within an EMS environment.
9. Briefly define the purpose of Distribution Automation (DA) and a Distribution Management System (DMS) in modern power systems.
10. Write two examples of customer automation functions enabled by DA/DMS technologies.

PART B

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

11. Explain the architecture and components of a SCADA system. Discuss its basic functions and application functions in generation, transmission, and distribution of power, highlighting the advantages of using SCADA in power systems.

(14 marks)

OR

12. With the help of a functional block diagram, explain the hardware and software architecture of an Intelligent Electronic Device (IED).

(14 marks)

13. (a) Describe and draw diagrams for any four standard SCADA communication topologies. Discuss their respective advantages and disadvantages in a large power system.

(7 marks)

- (b) Discuss the significant security for SCADA and smart grid communication requirements and the challenges faced in securing these critical infrastructure networks. Propose potential mitigation strategies against common cyber threats.

(7marks)

OR

14. Explain the role and features of key SCADA and smart grid protocols such as DNP3 and IEC 61850. Highlight why IEC 61850 is considered a significant advancement for substation automation.

(14 marks)

15. With the help of diagrams, describe the hierarchical architectures of a modern substation automation system, detailing the function of the station level, bay level, and process level.

(14 marks)

OR

16. Discuss the practical implementation steps involved in deploying a modern substation automation system, from design and testing phases through commissioning.

(14 marks)

17. Describe the comprehensive EMS framework with the help of a functional block diagram. Explain how data flows from acquisition to application functions.

(14 marks)

OR

18. Explain how EMS with WAMS (Wide-Area Measurement Systems) enhances situational awareness and stability management in a smart transmission environment.

(14 marks)

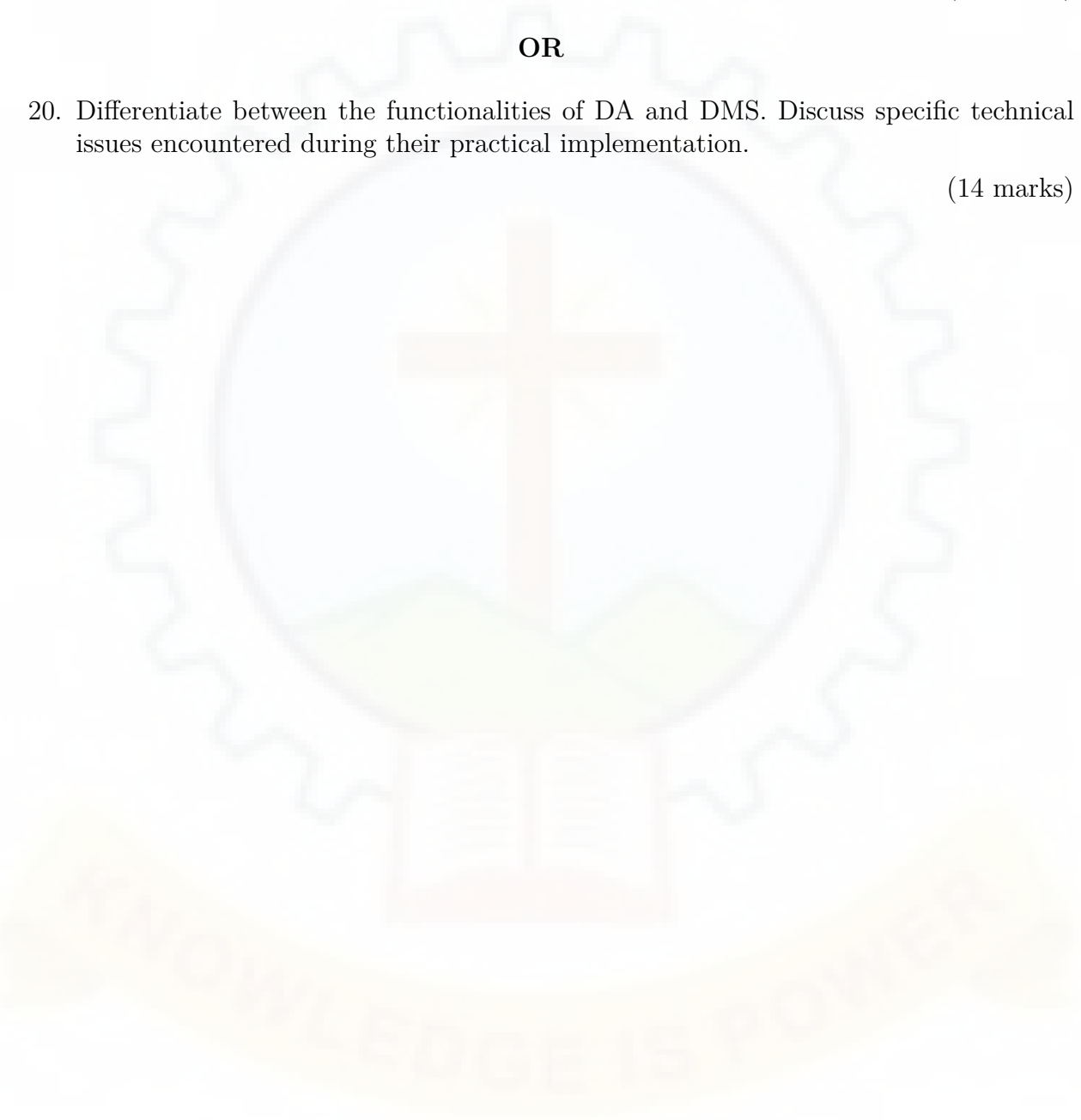
19. Describe the comprehensive DMS framework with the help of a functional block diagram, explaining how various subsystems integrate at the distribution control center.

(14 marks)

OR

20. Differentiate between the functionalities of DA and DMS. Discuss specific technical issues encountered during their practical implementation.

(14 marks)





HONOURS

B24EEH61	ANALYSIS OF POWER ELECTRONIC CIRCUITS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5		

Preamble

This course introduces the principles of designing, analysing, and protecting power electronic circuits. It covers drive and protection circuits, rectifiers, inverter topologies, modulation methods, and resonant converters. Students will be able to analyse converter operation and apply appropriate control, modulation, and protection strategies in practical systems.

Prerequisites

Circuits and Networks, Power Electronics

Course Outcomes

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

CO 1	Design gate/base drive circuits and protection schemes for power semiconductor devices using discrete components and gate-driver ICs. (Cognitive Knowledge Level: Apply)
CO 2	Analyze the operation of single-phase and three-phase phase-controlled rectifiers under different load conditions and source inductance effects. (Cognitive Knowledge Level: Analyze)
CO 3	Compare and evaluate multilevel inverter topologies, AC voltage controllers, and matrix converters based on their operation and application requirements. (Cognitive Knowledge Level: Apply)
CO 4	Implement space vector modulation, selective harmonic elimination, and current-control strategies for voltage-source inverters. (Cognitive Knowledge Level: Apply)
CO 5	Explain and differentiate various resonant converter topologies and assess their suitability for high-frequency power conversion. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	2	1	1	1	1			1
CO 2	3	2	2	2	2	2	1	1			1
CO 3	3	2	3	2	1	2	1	1			1
CO 4	3	2	2	2	1	2	1	1			1
CO 5	3	2	1	2	1	2	1	1			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/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 (12 hours)

Design of Gate Drive Circuits and Protection Schemes

Gate drive requirements and gate/base drive design - SCRs, BJTs, MOSFETs, IGBTs. Gate drive design - open collector, totem pole, non-isolated and isolated, optocoupler, pulse transformer based. Use of ICs- DS0026, TLP250, high side and low side switch driving using isolated gate drivers. Bootstrap technique for gate drives - IC IR 2110. Snubber circuits - function and types of snubber circuits, design of turn -off and turn-on snubber. Thermal protection - cooling, design and selection of heat sinks.

MODULE 2 (8 hours)

Phase Controlled Rectifiers

Single-phase converter - full converter, semi-converter, analysis with RLE loads - continuous and discontinuous conduction, inversion mode, effect of source inductance. Effect of single-phase rectifiers on neutral currents in three-phase four-wire systems. Three-phase converter - full converter, semi converter, analysis with RLE loads, inversion mode, effect of source inductance, line notching, and distortion.

MODULE 3 (8 hours)

Multi-level Inverters and AC Voltage Controllers

Multi-level inverters - diode clamped, flying capacitor, cascaded H-bridge. Three-phase AC voltage controllers - principle, operation, analysis with R loads. Matrix converters - three-phase to three-phase matrix converter, switching combinations, operation and control methods, commutation and protection issues, applications.

MODULE 4 (9 hours)

Advanced Control Techniques for Inverters

Concept of space vector - space vector modulation, reference vector and switching times, space vector sequence, comparison of sine PWM and space vector PWM. Selective harmonic elimination switching. Current-controlled voltage source inverter - hysteresis current control. Bus clamping PWM, advanced bus clamping PWM.

Seminar on recent trends in power electronic converter control techniques (not for evaluation).

MODULE 5 (8 hours)

Resonant Converters

Resonant circuit concepts, series resonant circuit, parallel resonant circuit, load resonant converter. ZCS resonant converter - L type, M type. ZVS resonant converter. Comparison of ZCS and ZVS resonant converters.

Use MATLAB/LTspice to simulate basic resonant converter circuits (not for evaluation).

Text Books

1. Robert W. Erickson and Dragan Maksimovic, *Fundamentals of Power Electronics*, Springer Science and Business Media, 2nd ed., 2007.
2. Ned Mohan, Tore M. Undeland, and William P. Robbins, *Power Electronics: Converters, Applications, and Design*, Wiley Publishers, 3rd ed., 2002.
3. M. H. Rashid, *Power Electronics: Circuits, Devices, and Applications*, Pearson Education, 4th ed., 2013.
4. L. Umanand, *Power Electronics – Essentials & Applications*, Wiley-India, 2009.
5. Simon Ang and Alejandro Oliva, *Power Switching Converters*, Taylor and Francis, 3rd ed., 2010.

Reference Books

1. Joseph Vithayathil, *Power Electronics: Principles and Applications*, Tata McGraw Hill, 2010.
2. M H Rashid (Ed), *Power Electronics Handbook: Devices, Circuits and Applications*, Academic Press, 2010.
3. William Shepherd and Li Zhang, *Power Converter Circuits*, Marcel Dekker Inc, 1st ed., 2004.
4. D. Grahame Holmes and Thomas A. Lipo, *Pulse Width Modulation for Power Converters: Principles and Practice*, Wiley, 1st ed., 2003.
5. Barry Williams, *Principles and Elements of Power Electronics*, University of Strathclyde, 1st ed., 1992.
6. Krein P. T., *Elements of Power Electronics*, Oxford University Press, 1998.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Design of Gate Drive Circuits and Protection Schemes	12
1.1	Gate and base drive design: Gate drive requirements and gate/base drive design for SCRs, BJTs, MOSFETs, IGBTs	3
1.2	Gate drive design using discrete components - open collector, totem pole, non-isolated and isolated- optocoupler, pulse transformer based, use of ICs such as DS0026, TLP250	3
1.3	High side and low side switch driving using isolated gate drivers. Bootstrap technique for gate drives using gate drive IC IR 2110	2
1.4	Design of protection elements: Snubber circuits: Function and types of Snubber circuits, design of turn -off and turn-on snubber	2
1.5	Thermal protection, cooling, design and selection of heat sinks (natural cooling only)	2
	Module 2: Phase Controlled Rectifiers	8
2.1	Single-phase converter - semi converter, analysis with RLE loads, discontinuous continuous conduction, inversion mode, effect of source inductance	2
2.2	Single-phase converter - full converter, analysis with RLE loads, discontinuous continuous conduction, inversion mode	1
2.3	Effect of source inductance (single phase converter), effect of single phase rectifiers on neutral currents in three phase four wire systems	1
2.4	Three-phase converter-semi converter, analysis with RLE loads, inversion mode	2
2.5	Three-phase converter - full converter, analysis with RLE loads, inversion mode, effect of source inductance, line notching and distortion	2
	Module 3: Multi-level Inverters and AC Voltage Controllers	8
3.1	Multi-level inverters- diode clamped	1
3.2	Multi-level inverters-flying capacitor, cascaded H-bridge	2
3.3	Three-phase AC voltage controllers-principle, operation, analysis with R loads	2
3.4	Matrix Converters- three phase to three phase matrix converter, switching combinations, operation and control methods	2

3.5	Matrix Converters- commutation and protection Issues, applications	1
	Module 4: Advanced Control Techniques for Inverters	9
4.1	Concept of space vector – space vector modulation, reference vector and switching times, space vector sequence	2
4.2	Comparison of sine PWM and space vector PWM	1
4.3	Selective harmonic elimination switching	2
4.4	Current-controlled voltage source inverter - hysteresis current control	2
4.5	Bus clamping PWM and advanced bus clamping PWM	2
	Module 5: Resonant Converters	8
5.1	Resonant Converters - resonant circuit concepts	1
5.2	Series resonant circuit	1
5.3	Resonant Converters - parallel resonant circuit, load resonant converter	2
5.4	ZCS resonant converter - L type, M type	2
5.5	ZVS resonant converter. Comparison of ZCS and ZVS resonant converters	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Design a gate-drive circuit for an IGBT.
2. Propose a complete snubber and thermal protection scheme for an SCR-based converter.
3. Develop a gate-drive solution using a bootstrap IC (IR2110).

Course Outcome 2 (CO 2)

1. Analyze the effect of source inductance on the output voltage of a single-phase full converter.
2. Compare the conduction modes (continuous vs. discontinuous) for a semi-converter.
3. Examine the impact of neutral currents generated by single-phase rectifiers.

Course Outcome 3 (CO 3)

1. Evaluate which multilevel inverter topology is most suitable for medium-voltage applications.
2. Judge the performance of AC voltage controllers when supplying an RL load.
3. Compare matrix converters with conventional rectifier-inverter systems.

Course Outcome 4 (CO 4)

1. Apply the space vector modulation method to determine the switching sequence for a given reference vector.
2. Use selective harmonic elimination to calculate switching angles that remove specific harmonics.
3. Implement hysteresis current control for a VSI and determine how it affects switching frequency.

Course Outcome 5 (CO 5)

1. Explain the operating principle of a series resonant converter and sketch its key waveforms.
2. Describe the differences between ZCS and ZVS resonant converters with respect to switching transitions.
3. Justify the choice between series and parallel resonant converters.

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: : B24EEH61

Course Name: : ANALYSIS OF POWER ELECTRONIC CIRCUITS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the function of a totem-pole gate driver and mention one advantage over an open-collector driver.
2. What is the purpose of a turn-off snubber circuit? Draw its basic structure.
3. Explain how source inductance affects the output voltage of a single-phase full converter.
4. State the conditions for continuous and discontinuous conduction in a single-phase semi-converter feeding an RLE load.
5. Compare diode-clamped and flying-capacitor multilevel inverters in terms of switch count and voltage balancing.
6. Draw the basic structure of a three-phase AC voltage controller and briefly explain its working with R-load.
7. Explain the concept of a reference vector in Space Vector Modulation (SVM).
8. What is hysteresis current control? Sketch the principle of operation with a simple diagram.
9. Differentiate between ZCS and ZVS resonant converters with respect to switching loss reduction.
10. Explain the operation of a series resonant converter.

PART B

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

11. Design the gate-drive system for an IGBT used in a high-frequency inverter. Include:
(i) required gate-drive voltage levels
(ii) isolated gate driving using a TLP250 driver IC
(iii) design of turn-on and turn-off snubbers. (14 marks)

OR

12. Explain the operation of bootstrap high-side gate driving using IR2110. Derive the condition for maintaining bootstrap capacitor charge. (14 marks)
13. Derive the expression for the average output voltage of a single-phase full converter feeding an RLE load under continuous conduction. (14 marks)

OR

14. Analyze a three-phase semi-converter feeding an R-load. Draw the complete waveforms for output voltage, device conduction intervals, and input current. Explain how line notching occurs and its impact on source harmonic distortion. (14 marks)
15. With neat diagrams, explain the operation of flying-capacitor multilevel inverter. Compare it with cascaded H bridge inverter in terms of switching losses, harmonic performance, voltage balancing, and application suitability. (14 marks)

OR

16. Explain the working principle of a three-phase matrix converter. Derive the switching functions needed to obtain sinusoidal input and output currents. Discuss commutation problems and propose a safe-commutation strategy with diagram. (14 marks)
17. Derive the switching time expressions for Space Vector Modulation (SVM). Construct the switching sequence for one sector and compare the harmonic performance with sinusoidal PWM. Include phasor diagrams and switching table. (14 marks)

OR

18. Explain the Selective Harmonic Elimination (SHE) technique for a voltage source inverter. Starting from the Fourier series expansion of the output, derive the transcendental equations for eliminating 5th and 7th harmonics. (14 marks)
19. Draw and explain the operation of a series resonant converter (SRC). Derive its voltage-gain characteristic for: (a) below-resonance, (b) at resonance, and (c) above-resonance operation. Discuss the effect of load variation on converter performance. (14 marks)

OR

20. Explain the operation of ZVS resonant converter with circuit diagram. Derive the conditions required for achieving soft switching. (14 marks)

B24EEH62	POWER SYSTEM DYNAMICS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

Power system stability is a critical requirement for the secure and reliable operation of modern interconnected power networks operating under varying load and disturbance conditions. This course focuses on the modelling and dynamic analysis of synchronous machines, small signal stability, multimachine systems, subsynchronous resonance, and voltage stability phenomena. The course equips students with analytical enhancement techniques necessary for planning, operation, and control of power systems.

Prerequisites

Circuits and Networks, Power System 1

Course Outcomes

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

CO 1	Assess power system stability concepts and develop mathematical models of synchronous machines using d–q transformation, per-unit representation, and steady-state equivalent circuits. (Cognitive Knowledge Level: Apply)
CO 2	Apply state-space modelling and eigenvalue analysis to evaluate small signal stability of a single machine infinite bus system, including synchronising and damping torque analysis. (Cognitive Knowledge Level: Apply)
CO 3	Analyse multimachine power system dynamics using centre-of-inertia reference, modal analysis, and assess local and inter-area oscillations, including the role of power system stabiliser. (Cognitive Knowledge Level: Apply)
CO 4	Asses subsynchronous resonance phenomena in series-compensated systems and evaluate countermeasures using mechanical–electrical system modelling and damping techniques. (Cognitive Knowledge Level: Apply)
CO 5	Analyse voltage stability using PV, QV, and PQ curves, assess voltage stability limits and indices, and evaluate methods for voltage stability improvement. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	1							1
CO 2	3	2	2	1							1
CO 3	3	2	2	1							1
CO 4	3	2	2	1							1
CO 5	3	2	1	1							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/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 (10 hours)

Power System Stability and Machine Modelling

Introduction to power system stability, modelling of synchronous machines, armature and field structure, parks transformation, machine with multiple pole pairs - mathematical description, d-q transformation, per unit representation, equivalent circuit for d-q axes, steady state analysis - voltage-current and flux linkage, phasor representation, rotor angle - steady state equivalent circuit.

MODULE 2 (9 hours)

Small Signal Stability

State space representation concept, eigen properties of the state vectors, analysis of stability, small signal stability of a single machine connected to infinite bus system - rotor mechanical equations, torque angle loop, representation of flux decay and excitation system, Heffron-Phillips constants, system representation, synchronising and damping torque analysis.

MODULE 3 (9 hours)

Analysis of Multimachine System

System model - generator equations and centre of inertia reference, formulation of state equations, representation of static loads, redundant state variables, modal analysis of large power systems.

Characteristics of small signal stability problems - local problems, global problems - illustrations using inter-area oscillations.

Power System Stabilizer (PSS) - basic concepts.

MODULE 4 (8 hours)

Analysis of Subsynchronous Resonance and Countermeasures

Subsynchronous Resonance (SSR) - SSR in series compensated systems, modelling of mechanical system, analysis of the mechanical system - analogy with electrical network, determination of modal inertia, analysis of the combined system.

Countermeasures -the problem of SSR, system planning considerations, filtering schemes, damping schemes.

MODULE 5 (9 hours)

Voltage Stability Analysis

Voltage stability problem, factors affecting voltage instability and collapse, real and reactive power flow in long transmission lines, effect of ULTC (under load tap changers) and load characteristics on voltage stability, voltage stability limit, voltage stability assessment using PV curves, QV curve, PQ curve – analysis with static loads - loadability limit, voltage collapse proximity indices, voltage stability improvement methods.

Text Books

1. P. Kundur, *Power System Stability and Control*, McGraw-Hill Education, 2nd ed., 2023.
2. K. R. Padiyar, *Power System Dynamics, Stability and Control*, BS Publications, 3rd ed., 2022.
3. Vijay Vittal, James D. McCalley, Paul M. Anderson, A. A. Fouad, *Power System Control and Stability*, Wiley-IEEE Press, 3rd ed., 2019.
4. C. W. Taylor, *Power System Voltage Stability*, McGraw-Hill, 1st ed., 1994.

Reference Books

1. M. A. Pai, D. P. Sen Gupta, K. R. Padiyar, *Small Signal Analysis of Power Systems*, Narosa Series in Power and Energy Systems, 2007.
2. C. Van Cutsem and T. Vournas, *Voltage Stability of Electric Power Systems*, Springer (Power Electronics and Power Systems), 1st ed., 1998.
3. Arthur R. Bergen and Vijay Vittal, *Power Systems Analysis*, Pearson Education, 2nd ed., 1999.
4. Jan Machowski, Janusz W. Bialek, Jim Bumby, *Power System Dynamics: Stability and Control*, John Wiley & Sons, 3rd ed., 2020.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Power System Stability and Machine Modelling	10

1.1	Introduction to power system stability	1
1.2	Modelling of synchronous machines, armature and field structure, Parks transformation	1
1.3	Machine with multiple pole pairs - mathematical description	2
1.4	D-Q transformation	1
1.5	Per unit representation, equivalent circuit for d-q axes	2
1.6	Steady state analysis - voltage-current and flux linkage	1
1.7	Phasor representation, rotor angle - steady state equivalent circuit	2
	Module 2: Small Signal Stability	9
2.1	Introduction to small signal stability, state space representation concept	1
2.2	Eigen properties of the state vectors	1
2.3	Analysis of stability, small signal stability of a single machine connected to infinite bus system	2
2.4	Rotor mechanical equations, torque angle loop, representation of flux decay and excitation system	2
2.5	Heffron-Phillips constants	1
2.6	System representation, synchronising and damping torque analysis	2
	Module 3: Analysis of Multimachine System	9
3.1	System model - generator equations and centre of inertia reference	2
3.2	Formulation of state equations	1
3.3	Representation of static loads, redundant state variables	1
3.4	Modal analysis of large power systems	1
3.5	Characteristics of small signal stability problems - local problems, global problems	2
3.6	Illustrations using inter-area oscillations	1
3.7	Power System Stabilizer (PSS) - basic concepts	1
	Module 4: Analysis of Subsynchronous Resonance and Countermeasures	8
4.1	Subsynchronous Resonance (SSR)	1
4.2	SSR in series compensated systems, modelling of mechanical system, analysis of the mechanical system	2
4.3	Analogy with electrical network, determination of modal inertia, analysis of the combined system	1
4.4	Countermeasures -the problem of SSR	1
4.5	System planning considerations	1
4.6	Filtering schemes	1
4.7	Damping schemes	1
	Module 5: Voltage Stability Analysis	9
5.1	Voltage stability problem	1
5.2	Factors affecting voltage instability and collapse, real and reactive power flow in long transmission lines	2

5.3	Effect of ULTC (under load tap changers) and load characteristics on voltage stability	1
5.4	Voltage stability limit, voltage stability assessment using PV curves, QV curve, PQ curve	2
5.5	Analysis with static loads - loadability limit	1
5.6	Voltage collapse proximity indices, voltage stability improvement methods	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Classify stability problems in modern power systems.
2. Why is d-q modelling preferred for dynamic analysis?
3. What is Park's transformation? Why is it used?

Course Outcome 2 (CO 2)

1. Illustrate state space representation with respect to power system dynamics.
2. Explain damping torque coefficient.
3. Define Heffron-Phillips constants.

Course Outcome 3 (CO 3)

1. State the need for using the centre of inertia reference in multimachine analysis.
2. What are the characteristics of small signal stability problems?
3. Explain the basic objectives of Power System Stabilizer (PSS)?

Course Outcome 4 (CO 4)

1. Define subsynchronous resonance.
2. What is meant by electrical resonance in series-compensated systems?
3. Explain filtering scheme for subsynchronous resonance mitigation.

Course Outcome 5 (CO 5)

1. What is meant by voltage collapse?
2. List the factors affecting voltage instability.
3. Define loadability limit of a power system.



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: : B24EEH62

Course Name: : POWER SYSTEM DYNAMICS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. List the major classifications of power system stability.
2. What is Park's transformation? Why is it used?
3. Define Heffron–Phillips constants.
4. Explain how flux decay dynamics are represented in small signal models of synchronous machines.
5. Define the centre of inertia (COI) reference frame.
6. What are redundant state variables?
7. Explain how series compensation can lead to subsynchronous resonance.
8. What is a filtering scheme for SSR mitigation?
9. How ULTC action affects voltage stability ?
10. Define the loadability limit of a power system.

PART B

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

11. Derive the voltage equations of a synchronous machine in d-q reference frame and illustrate the physical interpretation of d-q transformation. (14 marks)

OR

12. Discuss the phasor representation of a synchronous machine in steady state. (14 marks)
13. Obtain the rotor mechanical equations for a synchronous machine used in small signal stability studies. (14 marks)

OR

14. Describe synchronising and damping torque analysis. Derive expressions and discuss their role in stability. (14 marks)
15. Illustrate the representation of static loads in small signal stability analysis of multi-machine systems. (14 marks)

OR

16. Differentiate between local and global (inter-area) small signal stability problems with suitable illustrations. (14 marks)
17. Illustrate the electrical-mechanical analogy used in SSR studies and show how a mechanical system can be represented as an equivalent electrical network. (14 marks)

OR

18. Describe damping schemes used to mitigate subsynchronous resonance, including torsional and electrical damping methods. (14 marks)
19. Discuss the major factors leading to voltage instability and voltage collapse. (14 marks)

OR

20. Analyse voltage stability using PV curves and QV curves. (14 marks)

B24EEH63	GENERALIZED MACHINE THEORY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course aims to provide a unified approach to understand and analyze various types of electrical machines. It gives the basics of mathematical-machine modelling and generalized approach leads to steady-state, transient and dynamic analysis. Upon successful completion of this course student can analyse and model various types of electrical machines using a unified approach.

Prerequisites

Electrical Machine I, Electrical Machine II

Course Outcomes

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

CO 1	Develop the basic two pole model representation of electrical machines using the basic concepts of generalized theory. (Cognitive Knowledge Level: Understand)
CO 2	Develop the linear transformation equations of rotating electrical machines incorporating the concept of power invariance. (Cognitive Knowledge Level: Apply)
CO 3	Apply linear transformation for the steady state and transient analysis of different types of rotating electrical machines. (Cognitive Knowledge Level: Apply)
CO 4	Analyze the polyphase synchronous machines, balanced three-phase steady-state and transient performance. (Cognitive Knowledge Level: Apply)
CO 5	Develop the electromagnetic torque equations of a single phase induction motor using the primitive machine model. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	3	3							2
CO 2	3	3	3	3	2						2
CO 3	3	3	3	3	2						2
CO 4	3	3	3	3							1
CO 5	3	3	3	3							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/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 (10 hours)

Unified Approach to the Analysis of Electrical Machine Performance

Basic two pole model of rotating machines, per unit system, transformer with a movable secondary, transformer and speed voltages in the armature, Kron's primitive machine, analysis of electrical machines.

MODULE 2 (8 hours)

Linear Transformations in Machines

Transformations in electrical machines, power invariance, transformation from a displaced brush axis, transformation from three phases to two phases, transformation from rotating axis to stationary axis, physical concepts of Park's transformations, transformed impedance matrix, electrical torques.

Use simulation software like MATLAB/Simulink for mathematical modelling of electrical machines using transformation (Assignment only)

MODULE 3 (10 hours)

DC Machines

Separately excited DC generators, separately excited DC motors, interconnection of machines, transfer function of DC machines, steady state analysis and characteristics - DC series motor, DC shunt machines, DC compound machine.

Use simulation software like MATLAB/Simulink for mathematical modelling of DC machines (Assignment only)

MODULE 4 (10 hours)

Polyphase Synchronous Machines

Basic synchronous machine parameters, general machine equation, three-phase synchronous machine, balanced steady state analysis, steady state power angle characteristics, short circuit ratio, transient analysis, and transient torque.

MODULE 5 (7 hours)

Polyphase Induction Machines

Transformations, electrical performance equations, analysis of the equivalent circuit, torque-slip Characteristics.

Single Phase Motors

Single-phase induction motors - revolving field theory, equivalent circuit, cross-field theory, starting methods, single-phase synchronous motors.

Text Books

1. Bhimbra P. S, *Generalized Theory of Electrical Machines*, Khanna Publishers, 7th ed., 2021.
2. Jan A. Melkebeek, *Electric Machines and Drives: Fundamentals and Advanced Modelling*, Wiley, 1st ed., 2018.
3. A.E. Fitzgerald, Charles Kingsley Jr and Stephen D. Umans, *Electric Machinery*, McGraw-Hill Education, 6th ed., 2003.

Reference Books

1. Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff and Steven D. Pekarek, *Analysis of Electric Machinery and Drive Systems*, Wiley-IEEE Press, 4th ed., 2025.
2. V. Rajini and A. Saravanan, *Design of Electrical Machines*, PHI Learning Pvt. Ltd., 1st ed., 2015.
3. R. Ramanujam, *Modeling and Analysis of Electrical Machines*, Oxford University Press India, 1st ed., 2012.
4. M.V. Deshpande, *Electrical Machinery: Theory, Performance and Applications*, PHI Learning Pvt. Ltd, 1st ed., 2011.
5. Alexander SLangsdorf, *Theory of Alternating Current Machinery*, Tata McGraw Hill, 2nd revised ed., 2001.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Unified Approach to the Analysis of Electrical Machine Performance	10
1.1	Introduction essentials of rotating machines, conventions	1
1.2	Basic two pole machine-idealised machine diagram of DC compound machine, DC shunt machine, synchronous motor, induction motor, single phase AC motor	2
1.3	Per unit system, advantages of per unit system, expression for self inductance of a machine, mutual flux linking	1

1.4	Transformer and speed voltages in the armature, transformer with movable secondary	2
1.5	Kron's primitive machine, leakage flux in machines with more than two windings, voltage equations	2
1.6	Analysis of electrical machines, concept of phasors, operational method	2
	Module 2: Linear Transformations in Machines	8
2.1	Linear transformation in machines - power invariance, transformations from a displaced brush axis	2
2.2	Transformations from three phase to two phase (a,b,c) to $(\alpha, \beta, 0)$ transformation matrix	1
2.3	Transformations from two phase to two axis (α, β) to (d, q) transformation matrix	1
2.4	Transformations from three phase to two axis (a,b,c) to $(d, q, 0)$ transformation matrix	1
2.5	Physical concepts of Park's transformations	2
2.6	Transformed impedance matrix, electrical torque	1
	Module 3: DC Machines	10
3.1	DC machines, separately excited DC generators, rotational mutual inductance, steady state and transient analysis	2
3.2	Separately excited DC motors- steady state analysis, sudden application of inertia load	2
3.3	Interconnection of machines, Ward-Leonard system of speed control	1
3.4	DC series motor, schematic diagram of Primitive model, interconnection between armature and field, torque and speed expression, different characteristics	2
3.5	DC shunt motor, schematic diagram, primitive model, steady state analysis, torque-Current and speed-Current characteristics, condition for maximum torque	1
3.6	DC compound machine, schematic diagram, primitive model	2
	Module 4: Polyphase Synchronous Machines	10
4.1	Polyphase synchronous machine, basic structure, assumptions, parameters, synchronous resistance, inductance and mutual inductance between armature and field	3
4.2	General Machine equation voltage equations, phasor relations, three phase synchronous machine construction, principle of operation, types of rotors	3
4.3	Balanced steady state analysis generator motor operation, phasor diagrams, steady-state power angle characteristics power equation, torque angle, stability limit	2
4.4	Short circuit ratio (SCR) definition, significance, effect on regulation stability, transient analysis sudden load changes, transient reactance, transient torque causes, expression, damping, oscillations	2
	Module 5: Polyphase Induction Machines	7

5.1	Polyphase induction machine, voltage expression, transformations from α to d-q and vice versa, expression for electromagnetic torque	2
5.2	Electrical performance equations, equivalent circuit of an induction machine, torque-slip characteristics (starting torque, max torque, factors affecting)	2
	Single Phase Motors	
5.3	Revolving field theory, equivalent circuit of single phase induction motor, cross field theory	2
5.4	Starting methods (split-phase, capacitor start/run, shaded pole), single phase synchronous motors (principle applications)	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Describe the essential features of rotating electrical machines.
2. Draw the basic two pole machine diagram of DC Compound Machine.
3. Develop an expression for the electrical torque of the Kron's Primitive Machine.

Course Outcome 2 (CO 2)

1. Explain the physical significance of Park's transformations.
2. Explain the role of transformation in simplifying dynamic equations of machines.
3. Why are transformations required for the analysis of AC machines?

Course Outcome 3 (CO 3)

1. Derive the speed-to-armature voltage transfer function of a DC machine.
2. Compare and contrast the steady-state characteristics (specifically speed-torque and torque-armature current curves) of a DC series motor and a DC shunt machine.
3. Draw the generalized model of a DC series machine and derive the voltage equation in matrix form.

Course Outcome 4 (CO 4)

1. Define synchronous reactance and explain its significance.
2. Write the expression for electromagnetic power in a cylindrical-rotor synchronous machine.
3. Sketch and explain the steady-state power–angle characteristics of a synchronous motor.

Course Outcome 5 (CO 5)

1. Write the electrical performance equations of a three-phase induction motor.
2. Explain the revolving field theory of a single-phase induction motor.
3. List and briefly explain any two starting methods of single-phase induction motors.

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: : B24EEH63

Course Name: : GENERALIZED MACHINE THEORY

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Sketch the basic two pole representation of the following machines
i) DC shunt machine with interpoles ii) DC compound machine.
2. Explain linear transformations as used in electrical machines.
3. What is Kron's primitive machine?
4. Enumerate the limitations of generalized theory of electrical machines.
5. Derive an expression for rotational mutual inductance or motional inductance of DC generator.
6. Derive the transfer function of separately excited DC motor under on no load operation.
7. Draw the power angle characteristics of salient pole and cylindrical rotor synchronous machine.
8. Draw the torque slip characteristics of three phase Induction motor.
9. Explain equivalent circuit of single phase Induction motor.
10. Compare single phase and poly phase Induction motor.

PART B

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

11. (a) Write the voltage equations for Kron's primitive machine in matrix form. (9 marks)
- (b) Derive the expression for transformer and speed voltages in the armature along the quadrature axis. (5 marks)

OR

12. Derive electrical torque expression of Kron's primitive machine in terms of reluctance and show that no torque is produced by interaction between flux and current on the same axis. (14 marks)
13. Explain Park's transformations to transform currents between a rotating balanced three phase (a, b, c) winding to a pseudo stationary two phase (d, q) winding. Assume equal number of turns on all coils. (14 marks)

OR

14. (a) Explain the physical concept of Park's transformation. (7 marks)
- (b) Explain the term invariance of power as applied to electrical machines. Show the power invariance is maintained under this transformation. (7 marks)
15. (a) Derive the voltage and torque equation of a DC series motor from its generalized mathematical model. (7 marks)
- (b) Obtain the steady state analysis of a separately excited DC motor and plot the shunt characteristics. Also derive the expression for torque. (7 marks)

OR

16. (a) A separately excited DC generator gives a no load output voltage of 240 V at a speed of w_r and field current of 3 A. Find the generated emf per field ampere. (5 marks)
- (b) Investigate the transient behaviour of a separately excited DC generator under the following operating condition: Sudden application of a step field excitation to the field under no load, $i_a = 0$ and for constant no load speed w_r and explore the variation of armature voltage. (9 marks)

17. (a) Derive the power expression for salient pole synchronous machine in terms of load angle and draw the power angle characteristics.

(7 marks)

- (b) Derive the voltage equations in matrix form for a three phase synchronous machine with no amortisseurs.

(7 marks)

OR

18. Derive the equivalent circuit of a poly phase induction motor with the help of its generalized mathematical model.

(14 marks)

19. Derive the electromagnetic torque equations from the primitive machine model of a single phase induction motor by applying cross field theory.

(14 marks)

OR

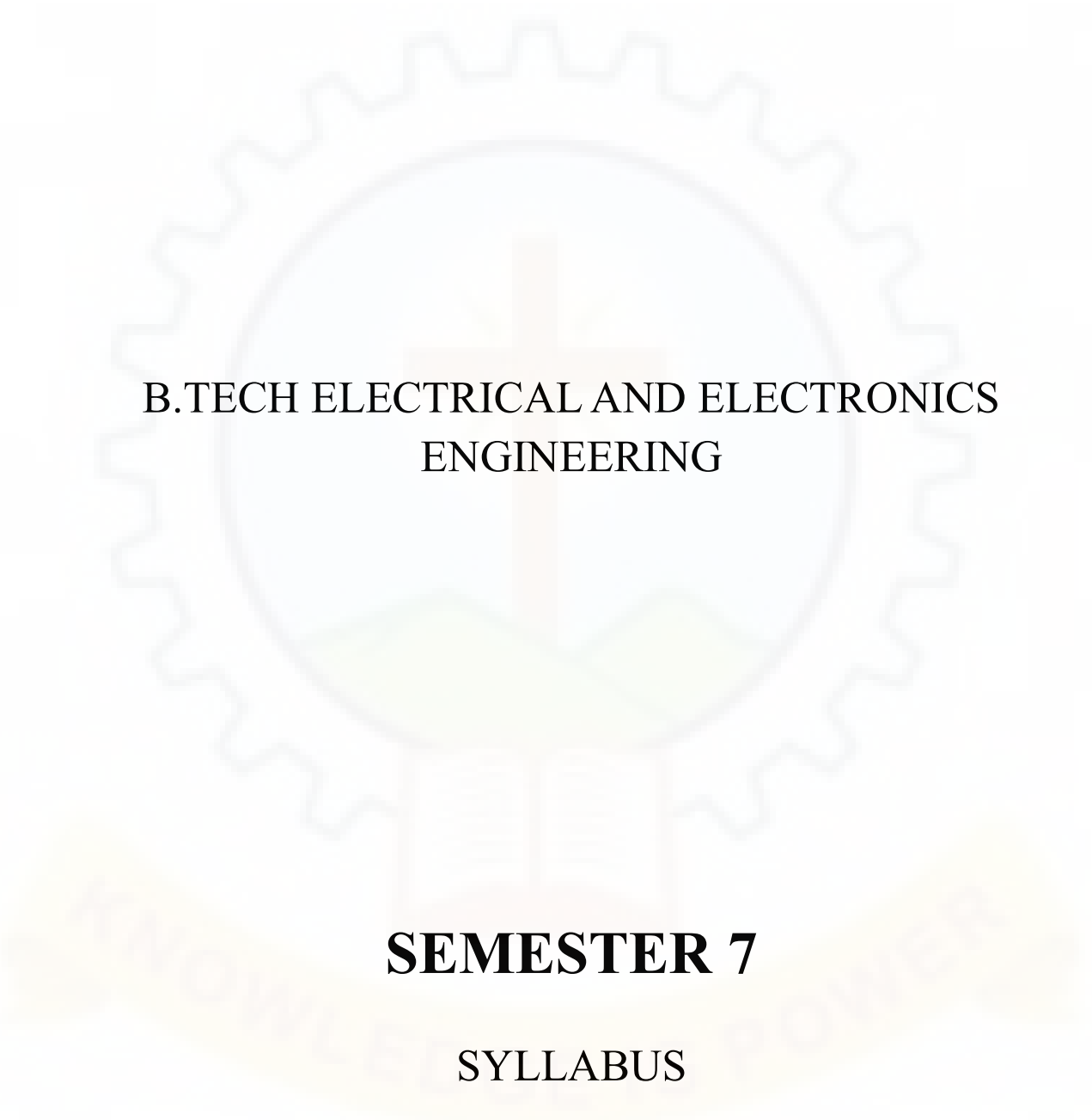
20. Explain the double field revolving theory of single-phase induction motor.

(14 marks)

MAR ATHANASIOUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution

Kothamangalam, Kerala, India



B.TECH ELECTRICAL AND ELECTRONICS ENGINEERING

SEMESTER 7

SYLLABUS

SEMESTER 7

SLOT	COURSE NO.	COURSES	L-T-P-S	HOURS	CREDIT
A	B24EE4T01	ELECTRICAL SYSTEM DESIGN AND ESTIMATION	2-1-0-4	3	3
B	B24EE4P3X	PROGRAMME ELECTIVE III	2-1-0-4	3	3
C	B24EE4P4X	PROGRAM ME ELECTIVE IV	2-1-0-4	3	3
D	B24EE4G2X	OPEN ELECTIVE II	2-1-0-4	3	3
E	B24HU4T04	DISASTER MANAGEMENT AND INDUSTRIAL SAFETY	2-1-0-4	3	3
G	B24EE4L11	POWER SYSTEMS LAB	0-0-3-2	3	2
H	B24EE4L12	PROJECT PHASE I	0-0-6-2	6	3
J	B24EE4L13	SEMINAR	0-0-4-1	4	2
K	B24EE4T02	VIVA VOCE	0-0-0-0	0	1
M	B24EEM7X	MINOR	3-1-0-5	4	4
N	B24EEH7X	HONOURS	3-1-0-5	4	4
TOTAL*				36	23

PROGRAMME ELECTIVE III

COURSE NO.	COURSES
B24EE4P31	ROBOTICS AND AUTOMATION
B24EE4P32	ELECTRIC VEHICLE TECHNOLOGY
B24EE4P33	POWER QUALITY
B24EE4P34	INTERNET OF THINGS
B24EE4P35	SOLID STATE DEVICES
B24EE4P36	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

PROGRAMME ELECTIVE IV

COURSE NO.	COURSES
B24EE4P41	DIGITAL CONTROL SYSTEM
B24EE4P42	ENERGY STORAGE SYSTEMS FOR EV
B24EE4P43	COMPUTER AIDED POWER SYSTEM ANALYSIS
B24EE4P44	DIGITAL IC DESIGN
B24EE4P45	DIGITAL SIGNAL PROCESSING
B24EE4P46	COMPUTER NETWORKS

OPEN ELECTIVE II

COURSE NO.	COURSES
B24EE4G21	BIOMEDICAL INSTRUMENTATION
B24EE4G22	INTRODUCTION TO ENERGY STORAGE SYSTEMS
B24EE4G23	ILLUMINATION ENGINEERING
B24EE4G24	ARTIFICIAL NEURAL NETWORKS AND FUZZY LOGIC SYSTEMS
B24EE4G25	ELECTRICAL SYSTEM DESIGN FOR BUILDINGS
B24EE4G26	SPECIAL MACHINES

MINOR

BASKET 1	
COURSE NO.	COURSE
B24EEM71	ROBOTICS AND AUTOMATION
BASKET 2	
COURSE NO.	COURSE
B24EEM72	HVDC TRANSMISSION
BASKET 3	
COURSE NO.	COURSE
B24EEM73	DISTRIBUTED GENERATION AND SMART GRID

HONOURS

BASKET 1	
COURSE NO.	COURSE
B24EEH71	DYNAMICS OF POWER CONVERTERS
BASKET 2	
COURSE NO.	COURSE
B24EEH72	CONTROL AND DYNAMICS OF MICROGRID
BASKET 3	
COURSE NO.	COURSE
B24EEH73	COMPUTATIONAL ELECTROMAGNETICS

B24EE4T01	ELECTRICAL SYSTEM DESIGN AND ESTIMATION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

To provide knowledge of electrical symbols, Indian Standard codes, Indian Electricity acts and NEC norms. The course addresses the electrical installation standards and regulations, lighting design principles, domestic and industrial wiring systems, protection and earthing practices, high-rise building installations, energy conservation techniques, and basic solar PV system design. By the end of the course, students will be able to design energy-efficient electrical installations in compliance with codes and regulations.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the relevance and application of Indian Standards, the National Electric Code, and the Electricity Act in the design of medium and high voltage electrical installations. (Cognitive Knowledge Level: Understand)
CO 2	Understand lighting fundamentals and perform illumination design calculations using standard methods for interior and exterior lighting applications. (Cognitive Knowledge Level: Apply)
CO 3	Design low/medium voltage domestic electrical installations. (Cognitive Knowledge Level: Apply)
CO 4	Design industrial electrical installations and 11 kV substation, select appropriate switchgear and protective devices, and carry out pre-commissioning tests. (Cognitive Knowledge Level: Apply)
CO 5	Design the high-rise building electrical installations including power backup systems, and understand energy conservation methods, and solar PV system design. (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	2	2		2	2				3
CO 2	3	3	2	2		2	1				3
CO 3	3	3	2	2		2	1				3
CO 4	3	3	2	2	2	2	1				3
CO 5	3	3	2	2		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/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 (6 hours)

Electrical Installation Standards and Regulations

Electrical Installations - general requirements, IS 732, IS 3043, IS 2026, IS 3646-part 1&2, IS 5216 part 1&2, Kerala Electricity supply code 2014 (Relevance of each code in electrical installation applications only). National Electric Code (NEC SP 30:2023) - graphical symbols and signs as per NEC for electrical installations. The Electricity Act 2003 - general introduction, distribution of electricity (Part VI), central electricity authority (Part IX), regulatory commissions (Part IX).

Classification of voltages - standards and specifications, tolerances for voltage and frequency.

MODULE 2 (7 hours)

Lighting Fundamentals and Illumination System Design

Lighting design calculations - luminous flux, lumen, luminous intensity/illuminance (Lux), illumination calculations, factors affecting Coefficients of Utilisation (CoU) and Light Loss Factor (LLF). Benefits of LED lamps over the yesteryear luminaires - efficacy of present-day LED lamps. Design of illumination systems - average lumen method -point to point method. Exterior lighting design - road lighting, public area lighting - selection of luminaires - Metal Halide, high & low pressure Sodium, LED lamps.

Case Study: Design of lighting systems for seminar hall, school and cinema theater (Assignment/Tutorial only).

MODULE 3 (8 hours)

Domestic Installation

Design of domestic dwellings - NEC and IS 732 regulations, load survey - connected load calculation, diversity factor, sub circuits (lighting and power). MCB, MCCB isolator, EL-CB/RCCB, and RCBO, selection of CBs, selection of wiring cables and conduits as per NEC and IS 732.

Design of electrical schematic and physical layout drawings - low and medium class domestic installation, schedule of works, bill of quantities (cost estimation excluded). Pre-commissioning tests - insulation resistance measurement, continuity test, polarity test, and earth resistance measurement.

MODULE 4 (8 hours)

Industrial Electrical Installations and Substation Design

Industrial installations - classifications, design of electrical distribution systems - main switch board, sub switch boards, distribution boards, ACB, MCCB and MCB. Design of MSB &

SSB including Motor Control Centre (MCC), selection of bus bars and switchgears. Safety of electrical installations - lightning protection, Surge Protection Devices.

Selection of 11 kV indoor and outdoor transformer substations (up to 630kVA), selection of switchgears and protective devices, preparation of schedule of works, bill of quantities (cost estimation excluded).

11 kV substation - design, short circuit calculation, earthing design - HV and LV sides (capacity up to 630 kVA), pre-commissioning tests - indoor/outdoor substation (HT consumer).

MODULE 5 (7 hours)

Electrical Installations of High-Rise Buildings, Diesel Generator Set (DG Set)

Distribution systems - rising main, cable system, Installation of lifts, standby generators, fire pumps - electrical schematic.

DG set - installation and essential protections, automatic mains failure (AMF) systems. Energy conservation techniques, Automatic Power Factor Correction (APFC) panel - principle of operation and advantages.

Solar PV Systems

Solar PV systems - introduction, off-grid and on-grid systems, solar panel efficiencies, design of a PV system - domestic application, selection of battery - off-grid domestic systems.

Text Books

1. M. K. Giridharan, *Electrical Systems Design*, I K International Publishers, 2nd ed., 2020.
2. J. B. Gupta, *A Course in Electrical Installation Estimating and Costing*, S.K. Kataria & Sons; Reprint 9th ed., 2018.
3. K. B. Raina, S. K. Bhattacharya, *Electrical Design Estimating and Costing*, New Age International Publishers, 3rd ed., 2024.

Reference Books

1. V K Jain, *Design of Electrical Installations*, Laxmi Publications, 2nd ed., 2016.
2. S K Battacharya, *Electrical Engineering Drawing*, New Age International Publishers, 3rd ed., 2022.
3. N Rajendran, *Design of Electrical systems*, 1st ed., 2014.
4. S L Uppal, *Electrical wiring, estimating and costing*, Khanna Publishers, 6th ed., 2025.
5. National Electrical Code SP 30:2023.
6. National Building Code, 2016.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Electrical Installation Standards and Regulations	6
1.1	Electrical Installations - general requirements, IS 732, IS 3043, IS 2026	1
1.2	IS 5216 part 1&2, Kerala Electricity supply code 2014 (Relevance of each code in electrical installation applications only)	1
1.3	National Electric Code (NEC SP 30:2023) - graphical symbols and signs as per NEC for electrical installations	1
1.4	IS 3646-part 1&2, The Electricity Act 2003 - general introduction, distribution of electricity (Part VI)	1
1.5	Central electricity authority (Part IX), regulatory commissions (Part IX)	1
1.6	Classification of voltages - standards and specifications, tolerances for voltage and frequency	1
	Module 2: Lighting Fundamentals and Illumination System Design	7
2.1	Lighting design calculations - luminous flux, lumen, luminous intensity/illuminance (Lux)	1
2.2	Illumination calculations, factors affecting Coefficients of Utilisation (CoU) and Light Loss Factor (LLF)	1
2.3	Benefits of LED lamps over the yesteryear luminaires - efficacy of present-day LED lamps	1
2.4	Design of illumination systems - average lumen method - point to point method	1
2.5	Exterior lighting design - road lighting	1
2.6	Public area lighting - selection of luminaires	1
2.7	Metal Halide, high & low pressure Sodium, LED lamps	1
	Module 3: Domestic Installation	8
3.1	Design of domestic dwellings - NEC and IS 732 regulations	1
3.2	Load survey - connected load calculation, diversity factor, sub circuits (lighting and power)	1
3.3	MCB, MCCB isolator, ELCB/ RCCB, and RCBO	1
3.4	Selection of CBs, selection of wiring cables and conduits as per NEC and IS 732	1
3.5	Design of electrical schematic and physical layout drawings - low and medium class domestic installation	1
3.6	Electrical installation-schedule of works, bill of quantities (cost estimation excluded)	1
3.7	Pre-commissioning tests - insulation resistance measurement, continuity test	1

3.8	Polarity test and earth resistance measurement	1
	Module 4: Industrial Electrical Installations and Substation Design	8
4.1	Industrial installations - classifications, design of electrical distribution systems	1
4.2	Main switch board, sub switch boards, distribution boards, ACB, MCCB and MCB	1
4.3	Design of MSB & SSB including motor control Centre (MCC), selection of bus bars and switchgears	1
4.4	Selection of 11 kV indoor and outdoor transformer substations (up to 630kVA), selection of switchgears and protective devices, preparation of schedule of works, bill of quantities (cost estimation excluded)	2
4.5	11 kV substation - design, short circuit calculation, earthing design - HV and LV sides (capacity up to 630 kVA)	2
4.6	Pre-commissioning tests - indoor/outdoor substation (HT consumer)	1
	Module 5: Electrical Installations of High-Rise Buildings, Diesel Generator set (DG Set)	7
5.1	Distribution systems - rising main, cable system, Installation of lifts, standby generators, fire pumps - electrical schematic	2
5.2	DG set – installation and essential protections, automatic mains failure (AMF) systems	2
5.3	Energy conservation techniques, Automatic Power Factor Correction (APFC) panel - principle of operation and advantages	1
5.4	Solar PV systems - introduction, off-grid and on-grid systems, solar panel efficiencies, design of a PV system - domestic application, selection of battery - off-grid domestic systems	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain IS 2026.
2. Significance of CEA.
3. Illustrate symbols and sign as per NEC.

Course Outcome 2 (CO 2)

1. Problems on lighting design.
2. Limitations of Sodium vapour lamps.
3. Design of public area lighting .

Course Outcome 3 (CO 3)

1. Explain working of RCCB.
2. Illustrate pre-commissioning tests for electrical installations.
3. Design of domestic installation.

Course Outcome 4 (CO 4)

1. Explain the selection of bus bars and switch gears.
2. Design and estimation for industrial installations.
3. Design of 11 kV substation. .

Course Outcome 5 (CO 5)

1. Outline the principle of AMF system.
2. Draw the diagram of on-grid solar power plant.
3. Design electrical installations for high rise buildings.

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EE4T01

Course Name: : ELECTRICAL SYSTEM DESIGN AND ESTIMATION

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Discuss the relevance of IS 3043.
2. Draw the standard symbols for circuit breaker, auto transformer starter and overhead line.
3. Illustrate the working of metal halide lamps.
4. Enumerate the factors affecting LLF.
5. Differentiate between MCB and MCCB.
6. Explain earth resistance measurement.
7. Select a cable size, starting device, SFU and fuse rating for a 3-phase, 415V, 50 Hz, 15 Hp Squirrel cage induction motor.
8. Draw single line diagram of a 11 kV/415 V outdoor substation with rating of components.
9. What are the rising main systems utilized in high-rise buildings? Draw a neat diagram.
10. Enumerate the advantages of Automatic power factor correction (APFC) panel.

PART B

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

11. Explain the salient features of NEC SP 30:2023. (14 marks)

OR

12. Explain the role of CEA and regulatory commissions. (14 marks)

13. (a) Explain the construction and working principle of High- Pressure Sodium Vapour lamps. (6 marks)

- (b) An assembly shop of 20 m long, 10 m wide and 4 m upto the truss is to be illuminated at a level of 220lux. Take Coefficient of Utilisation = 0.75 and maintenance factor = 0.8. Calculate the number of lamps required for the illumination system. Lumen output of lamp = 3500 lumens. Assume any other required data appropriately. (8 marks)

OR

14. (a) Explain the general considerations for a good interior lighting scheme.(6 marks)

- (b) A certain incandescent lamp, hangs from the ceiling of a room. The illuminance received on a small horizontal screen lying on a bench 2m vertically below the lamp is 63.5 lux. Calculate illuminance at a point when the screen is moved horizontally a distance of 1.5m along the bench. (8 marks)

15. A guest-house has six air-conditioned rooms with private bathrooms, a kitchen, and a dining room. Prepare a room-by-room list of electrical installation materials. Draw a schematic of the distribution board with MCB ratings and sub-circuits indicated. The design must conform to NEC specifications. Assume any other required data appropriately. (14 marks)

OR

16. (a) Explain the importance of pre-commissioning tests in a domestic wiring system. Discuss any two pre-commissioning tests for domestic installations. (8 marks)

- (b) Find the total connected load, type of supply, and number of sub circuits for a home with the following rooms: one bedroom with an attached bathroom, living room, dining room, and kitchen. Determine the number of light, fan, socket, and exhaust fan points required by NEC for the structure. Assume any other required data appropriately. (6 marks)

17. (a) Draw the single line diagram of a motor circuit wiring. What are the design criteria to be followed while selecting cable and circuit breaker for a motor circuit wiring? (5 marks)

- (b) For a 11kV HT consumer, design the earthing system and calculate the number of plate earth pits (size of plate: 1200mm x1200mm x12mm).Soil resistivity =100 Ω -m,current density for copper = 118A/mm²,11kV side fault current =8.704 kA. Assume any other required data appropriately. (9 marks)

OR

18. (a) A small workshop 30m x 20 m has to be equipped with the following machinery: (i) 5hp, 415V, 3phase induction motor (ii) 3hp, 415V, 3phase induction motor (iii) 0.5hp, 230V, 1 phase motor. Estimate the quantity of materials required for the installation. (6 marks)
- (b) In a village, residential load of 20 kW, agriculture load of 30 hp, and water pump of 10 hp has to be electrified. Make a list of materials for installing an outdoor substation with a single line diagram. (8 marks)
19. (a) Explain the principle of operation of an Automatic mains failure system in an electrical installation. (6 marks)
- (b) With neat diagram explain the different components of a solar PV system along with classification of systems. (8 marks)

OR

20. (a) Explain the methods to improve the energy efficiency of an electrical installation and its significance. (6 marks)
- (b) Design an Off grid solar PV system for domestic installations with daily usage energy of 3 units. (8 marks)

B24HU4T04	DISASTER MANAGEMENT AND INDUSTRIAL SAFETY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	2	3	2024

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

Nil

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. (Cognitive Knowledge Level: Understand)
CO 2	Apply remote sensing resolutions and risk analysis concepts to identify and predict hazards at various administrative levels.(Cognitive Knowledge Level: Apply)
CO 3	Utilize hazard identification techniques like HAZOP and FMEA to assess industrial risks and causation theories.(Cognitive Knowledge Level: Apply)
CO 4	Analyze industrial safety standards, fire safety protocols, and statutory provisions like the Factories Act and OSHA.(Cognitive Knowledge Level: Analyze)
CO 5	Evaluate ethical responsibilities and lessons from historical case studies to develop sustainable disaster prevention strategies.(Cognitive Knowledge Level: Evaluate)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
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		1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% 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 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 (8 hours)

Introduction to Disaster Management

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 (8 hours)

Disaster Preparedness, Mitigation, and Response

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 (7 hours)

Industrial Safety and Hazard Identification

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.

MODULE 4 (7 hours)

Industrial Safety Practices and Legislation

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 (6 hours)

Environmental Safety, Case Studies

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. Harsh K. Gupta, *Disaster Management*, Universities Press (Orient Black swan), 2003, ISBN: 9788173714566.
2. John R. Jensen, *Remote Sensing of the Environment: An Earth Resource Perspective*, 2nd Edition, Pearson Prentice Hall, Upper Saddle River, NJ, 2007, ISBN: 9780131889507.
3. K. U. Mistry, *Fundamentals of Industrial Safety and Health (Vol. 1 and 2)*, 4th Edition, Siddharth, 2022.

Reference Books

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

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Introduction to Disaster Management	8
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.	2
1.3	Impacts of disasters on human life, infrastructure, economy, and environment.	2
1.4	Disaster management cycle: prevention, mitigation, preparedness, response, recovery.	2
	Module 2: Disaster Preparedness, Mitigation, and Response	8
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
	Module 3: Industrial Safety and Hazard Identification	7
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
	Module 4: Industrial Safety Practices and Legislation	7
4.1	Safety Legislation and 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 and Personal Protective Equipment (PPE).	2
	Module 5: Environmental Safety, Case Studies	6

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	Case studies: Bhopal Gas Tragedy, Chernobyl Nuclear Disaster, Fukushima Disaster.	1

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: 3

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 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.

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.
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.
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.
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.

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”. .

B24EE4L11	POWER SYSTEMS LAB	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

The aim of this lab course is to give students basic practical knowledge of power system analysis, control, protection, and testing. The experiments include power system modelling, load flow and stability analysis, automatic generation control, fault studies, relay and instrument transformer testing, insulation and earthing tests, and power factor improvement. After completing the laboratory, students will be able to analyse power system performance and apply practical methods used in real power system.

Prerequisite

Power Systems II

Course Outcomes

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

CO 1	Apply MATLAB tools to model power systems and analyse stability and automatic generation control of single- and two-area systems. (Cognitive Knowledge Level: Apply)
CO 2	Apply load flow and fault analysis techniques to assess power system performance under normal and faulted operating conditions. (Cognitive Knowledge Level: Apply)
CO 3	Test the operation of instrument transformers and protective relays used in power system protection. (Cognitive Knowledge Level: Apply)
CO 4	Conduct insulation, dielectric strength, earthing, and power factor improvement tests to assess safety, reliability, and efficiency of power systems. (Cognitive Knowledge Level: Apply)
CO 5	Develop the team management skills and prepare laboratory reports that logically and scientifically communicate experimental information. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Mark Distribution

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

Continuous Internal Evaluation Pattern

Attendance	10 marks
Continuous Assessment	15 marks
Viva-Voce/ Test	15 marks
Lab Record	5 marks
Microproject	5 marks

End Semester Examination (ESE) Pattern:

The following guidelines should be followed regarding the award of marks

1. Preliminary work: 25 Marks
 - (a) Circuit Diagram/Program: 15 Marks
 - (b) Theory/Design and Procedure: 10 Marks
2. Implementing the work/Conducting the experiment: 30 Marks (usage of equipment and troubleshooting)
3. Result and Inference: 15 Marks
4. Viva Voce: 30 Marks

Micro Project: Students must complete a mandatory micro project in groups of up to four members. The project shall involve the analysis/modelling/simulation/experimental investigation of a power system problem related to the experiments conducted in the Power Systems Lab. This project will be evaluated as part of the continuous internal evaluation, with a maximum of 5 marks. Students having a certified Lab Record and Micro Project Report are only eligible to appear for the End Semester Examination.

SYLLABUS

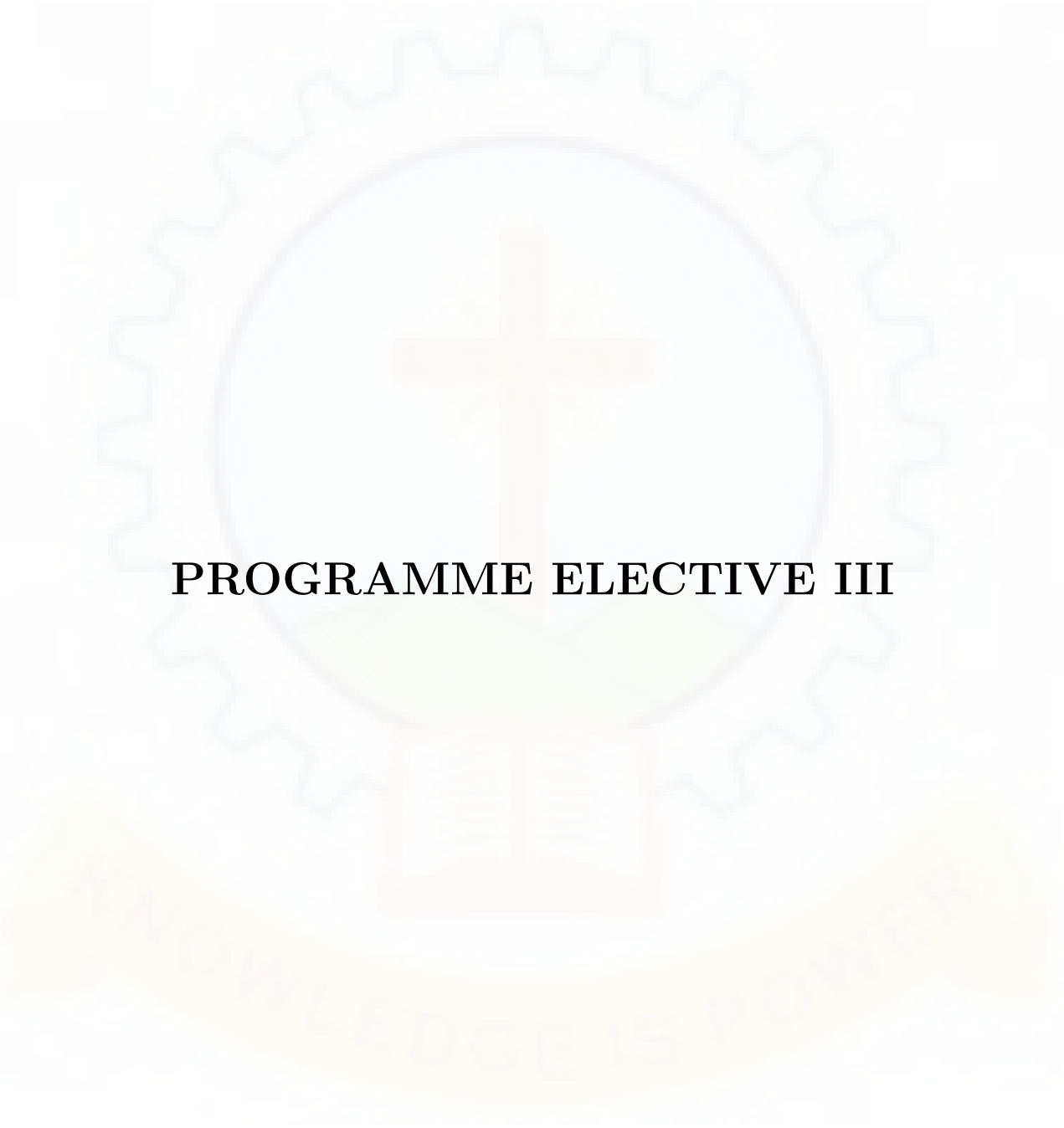
LIST OF EXPERIMENTS

1	Obtain the bus admittance matrix (Y_{BUS}) of the given power system network using any programming software.
2	Find the critical clearing angle by applying equal area criterion for a given power system network and plot the swing curve using any programming software.
3	Automatic generation control a) Construct the model of a single area power system network using any power system simulation software and obtain the power and frequency deviation responses. b) Construct the model of a two area power system network using any power system simulation software and obtain the power and frequency deviation responses.
4	Conduct the load flow analysis of the given power system network using any power system simulation software employing a) Gauss-Seidel method. b) Newton-Raphson method. c) Fast Decoupled Method.
5	Short Circuit Analysis a) Conduct the symmetrical fault analysis of the given power system network using any power system simulation software. b) Conduct the unsymmetrical fault analysis of the given power system network using any power system simulation software.
6	Conduct the ratio test of the given current transformer (CT) and potential transformer (PT).
7	Relay Testing a) Plot the operating time - current characteristics of over current relay (Electromechanical/Static/Numerical). b) Plot the operating time - current characteristics of over voltage relay (Electromechanical/Static/Numerical).

8	Determine the insulation resistance of the given LT & HT cables by using appropriate testing equipment.
9	Conduct high-voltage breakdown test on air to determine its dielectric strength.
10	Conduct high-voltage breakdown test on solid insulating materials to determine their dielectric strength.
11	Measure the earth resistance of the grounding system.
12	Determine the power factor of a single phase induction motor for a given load and improve it using capacitor bank.

Reference Books

1. D. P. Kothari, I. J. Nagrath, and R. K. Saket, *Modern Power System Analysis*, McGraw Hill, 5th ed., 2022.
2. John J. Grainger and William D. Stevenson, *Power System Analysis*, McGraw-Hill Education, 2nd ed., 2016.
3. Hadi Saadat, *Power System Analysis*, PSA Publishing, 3rd ed., 2011.
4. Kundur P., *Power system Stability and Control*, McGraw Hill, 2nd ed., 2022.
5. Gupta B. R., *Power System Analysis and Design*, S. Chand & Company, 2nd ed., 2008.
6. Uppal S. L. and S. Rao, *Electrical Power Systems*, Khanna Publishers, 15th ed., 2009.
7. Wadhwa C. L., *Electrical Power Systems*, New Age International, 8th ed., 2022.



PROGRAMME ELECTIVE III

B24EE4P31	ROBOTICS AND AUTOMATION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course aims to develop a solid conceptual and analytical foundation by combining theoretical principles with practical applications in modern robotic systems. It focuses on fundamentals of robotics and automation, covering robot anatomy, sensors, actuators, kinematics, dynamics and robot control. This course will help students to analyze, design, and apply robotic solutions effectively in diverse industrial automation and robotics-related careers.

Prerequisites

Linear control system, Advanced control system.

Course Outcomes

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

CO 1	Understand the fundamentals of robotics including robot anatomy, characteristics, degrees of freedom, types and sensing systems. (Cognitive Knowledge Level: Understand)
CO 2	Classify and select different actuators used for robotic applications and describe various robot configurations. (Cognitive Knowledge Level: Understand)
CO 3	Analyze robot kinematics and trajectory planning techniques. (Cognitive Knowledge Level: Apply)
CO 4	Develop dynamic models of robotic systems and its control strategies. (Cognitive Knowledge Level: Apply)
CO 5	Understand industrial automation principles and identify suitable solutions for industrial applications. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	40	20	20
Understand	60	40	40
Apply		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 (6 hours)

Introduction to Robotics

Definition and origin of robotics, types of robots - manipulators, mobile robots - wheeled and legged robots, aerial robots, robot anatomy - types of joints and end effectors, robot characteristics - accuracy, precision and repeatability, degrees of freedom.

Robotic sensors - touch, force, proximity and vision sensors, internal sensors and external sensors, robotic vision systems.

MODULE 2 (7 hours)

Actuators for Robots

Selection parameters, electric actuators - stepper motors, dc motors, dc servo motors and their drivers, ac motors, linear actuators, selection of motors, components and typical circuit of hydraulic actuators and pneumatic actuators, advantages and disadvantages.

Robot Configurations

Prismatic Prismatic Prismatic (PPP), Revolute Prismatic Prismatic (RPP), Revolute Revolute Prismatic (RRP), Revolute Revolute Revolute (RRR), features of SCARA, PUMA Robots.

MODULE 3 (9 hours)

Robot Kinematics

Direct kinematics, translations and rotations - fundamental and composite rotations, rigid motion representation using homogenous transformation matrix, coordinate transformations, forward and inverse kinematics - roll, yaw and pitch angles, Euler angles, DH representation, arm equation.

Trajectory Planning

Basics of trajectory planning, joint space technique - use of p-degree polynomial, cubic polynomial, cartesian space technique, position and orientation planning.

MODULE 4 (7 hours)

Dynamics of Robots

Inertia properties, Euler - Lagrange's equation, dynamic modelling of 1 DOF and 2 DOF robots.

Introduction to Robot Control

Control techniques, transfer function and state space representation, performance and stability of feedback control, PID control of a single link manipulator, selection of PID controller gains, nonlinear nature of manipulators.

MODULE 5 (7 hours)

Industrial Automation and Applications

General aspects, elements, applications, advantages and limitations of automation, types of automation, assembly automation equipment.

Welding, spray painting, grinding, material handling and transfer, machine loading and unloading, assembly operations, sorting of parts, case study - robotic configuration for pick and place robot.

Text Books

1. S.K. Saha, *Introduction to Robotics*, Tata McGraw Hill, 2nd ed., 2014
2. Saeed B. Niku, *Introduction to Robotics: Analysis, Control, Applications*, Wiley India Pvt Ltd, 2024.
3. R.K.Rajput, *Robotics and industrial automation*, S.Chand Limited, 2008
4. Mikell P. Groover, et al., *Industrial Robotics – Technology, Programming and Applications*, McGraw Hill, 2nd ed., 2012
5. R K Mittal and I J Nagrath, *Robotics and Control*, Tata McGraw Hill, New Delhi, 2003

Reference Books

1. John. J.Craig, *Introduction to Robotics: Mechanics and Control*, PHI, 2005.
2. Robert J. Schilling, *Fundamentals of Robotics: Analysis & Control*, Pearson Education, 2000
3. Klafter, R.D., Chmielewski, T.A, Negin, M, *Robotic Engineering An Integrated Approach*, PHI, 2007

4. Ashitava Ghosal, *Robotics, Fundamental concepts and analysis*, Oxford University Press, 2006
5. S. R. Deb, *Robotics Technology and Flexible Automation*, Tata McGraw Hill, New Delhi, 1994.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lec- ture/Tuto- rial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Robotics	6
1.1	Definition and origin of robotics, types of robots - manipulators	1
1.2	mobile robots - wheeled legged robots, aerial robots,	1
1.3	robot anatomy - types of joints and end effectors	1
1.4	robot characteristics - accuracy, precision and repeatability, degrees of freedom	1
1.5	Robotic sensors - touch, force, proximity and vision sensors, internal sensors	1
1.6	external sensors, robotic vision systems	1
	Module 2: Actuators for Robots, Robot Configurations	7
2.1	Selection parameters, electric actuators - stepper motors	1
2.2	dc motors, dc servo motors and their drivers	1
2.3	ac motors, linear actuators, selection of motors	1
2.4	components and typical circuit of hydraulic actuators	1
2.5	pneumatic actuators, advantages and disadvantages	1
2.6	Prismatic Prismatic Prismatic (PPP), Revolute Prismatic Prismatic (RPP), Revolute Revolute Prismatic (RRP), Revolute Revolute Revolute (RRR),	1
2.7	features of SCARA, PUMA Robots	1
	Module 3: Robot Kinematics, Trajectory Planning	9
3.1	Direct kinematics, translations and rotations - fundamental and composite rotations	1
3.2	rigid motion representation using homogenous transformation matrix,	1
3.3	coordinate transformations	1
3.4	forward and inverse kinematics - roll, yaw and pitch angles	1
3.5	Euler angles, DH representation, arm equation	1
3.6	Basics of trajectory planning, joint space technique.	1
3.7	use of p-degree polynomial, cubic polynomial	1
3.8	cartesian space technique, position and orientation planning	2
	Module 4: Dynamics of Robots, Introduction to Robot Control	7

4.1	Inertia properties, Euler-Lagrange's equation	1
4.2	dynamic modelling of 1 DOF robot	1
4.3	Control techniques, transfer function and state space representation	1
4.4	performance and stability of feedback control,	1
4.5	PID control of a single link manipulator	1
4.6	selection of PID controller gains	1
4.7	nonlinear nature of manipulators	1
	Module 5: Industrial Automation and Applications	7
5.1	General aspects, elements, applications, advantages and limitations of automation	1
5.2	types of automation	1
5.3	assembly automation equipment	2
5.4	Welding, spray painting, grinding, material handling and transfer	1
5.5	machine loading and unloading, assembly operations, sorting of parts	1
5.6	case study - robotic configuration for pick and place robot	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Position sensors are not preferred to obtain the velocity and acceleration. Give reason.
2. Describe the various joint configurations in a robotic manipulator.
3. Explain robotic vision system.

Course Outcome 2 (CO 2)

1. Draw the block diagram of a hydraulic actuator. Detail the components.
2. Explain the RRR robot configuration with a suitable diagram.
3. Draw a functional diagram of a PUMA robot in detail. List the parts.

Course Outcome 3 (CO 3)

1. Explain the arm equation of a robotic manipulator.
2. Compare joint space trajectory planning and Cartesian trajectory planning.

3. A frame is rotated 30 degree about X-axis and then 60 degree about Y-axis. Determine the composite rotation matrix.

Course Outcome 4 (CO 4)

1. Draw the block diagram of a PID controller and explain the components.
2. Explain the need for nonlinear control in robot manipulators.
3. A control system has a constant error signal $e(t) = 5e(t)$. The controller gains are $K_p = 2$, $K_i = 1$ and $K_d = 0.5$. Using the PID control law, determine the control output $u(t)$.

Course Outcome 5 (CO 5)

1. Define industrial automation.
2. Explain the working of assembly automation equipment such as feeders and conveyors.
3. Describe machine loading and unloading operation using robots.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EE4P31

Course Name: : ROBOTICS AND AUTOMATION

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define Precision, Accuracy, and Repeatability of a robot.
2. Explain external sensors with two examples.
3. Draw a neat diagram of PPP robot configuration.
4. Which type of actuator would be most suitable for unloading 1000 kg items from a die casting machine. Explain the reasoning behind your choice.
5. Define roll, yaw and pitch angle in robot orientation.
6. Differentiate between forward and inverse kinematics.
7. Compare transfer function and state space representation of a system.
8. State Euler–Lagrange equation.
9. State advantages and limitations of automation.
10. List common assembly automation equipment.

PART B

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

11. (a) Describe the general features of wheeled, legged and aerial robots. (8 marks)
(b) With the help of a diagram, explain the anatomy of a robotic manipulator. (6 marks)

OR

12. (a) Draw and explain position and velocity internal sensors. (8 marks)
(b) Describe the various sensor characteristics to be considered in the choice of the sensor for robotic application. (6 marks)
13. Explain different types of actuators used in robots and discuss their advantages and disadvantages. (14 marks)

OR

14. (a) Explain SCARA robot configuration with the help of a diagram. (7 marks)
(b) List the differences between RRP configuration and a SCARA robot. (7 marks)
15. (a) Describe the rigid body motion representation using homogeneous transformation matrix. (7 marks)
(b) Explain the Denavit–Hartenberg (DH) representation with parameters used in robot kinematics. (7 marks)

OR

16. (a) Explain the steps involved in robot trajectory planning. (7 marks)
(b) Derive the general equation of a p-degree polynomial trajectory and explain its use. (7 marks)
17. (a) Explain computed torque control in a robotic manipulator with the help of a diagram. (10 marks)
(b) Can PID control be used for nonlinear system? Explain the reasoning. (4 marks)

OR

18. Derive the dynamics for a 1 degree of freedom (DOF) robotic manipulator having a revolute joint. (14 marks)
19. (a) Explain the applications of robot in the following areas a) Welding b) Spray Painting. (7 marks)
(b) Describe the working principle of automated sorting systems. (7 marks)

OR

20. Classify various types of industrial automation and illustrate each with examples. (14 marks)

B24EE4P32	ELECTRIC VEHICLE TECHNOLOGY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course provides fundamental knowledge of Electric Vehicles (EVs). It introduces the fundamental concepts of electric vehicles, including the operating principles and characteristics of electric motors used in EVs. The course covers vehicle mechanics and electric propulsion systems, emphasizing their role in overall vehicle performance. In addition, the course addresses communication networks used in EV architectures. The course also introduces the fundamental concepts of autonomous vehicle systems, highlighting their basic components and functionalities.

Prerequisites

Nil

Course Outcomes

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

CO 1	Illustrate and explain the configurations and architectures of electric, hybrid electric, and plug-in hybrid electric vehicles (EV, HEV, and PHEV), and realize the fundamentals of power-component sizing. (Cognitive Knowledge Level: Understand)
CO 2	Apply vehicle kinematics and kinetics to determine velocity, acceleration, forces, and moments acting on vehicles. (Cognitive Knowledge Level: Apply)
CO 3	Identify and explain the electric drive components used in electric vehicle propulsion systems and their functional roles. (Cognitive Knowledge Level: Understand)
CO 4	Apply vehicle controllers and communication systems in electric vehicles using AUTOSAR and CAN-based architecture. (Cognitive Knowledge Level: Apply)
CO 5	Explain the architecture of Autonomous vehicles and battery energy storage systems used in electric vehicles. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1			1		1		1	2
CO 2	3	2	2			1		1		1	2
CO 3	3	2	1			1		1		1	2
CO 4	3	2	3		2	1		1		1	2
CO 5	3	2	2			1		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	60	60	60
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 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 (7 hours)

Introduction to Electric Vehicles

Need for electric vehicle, configuration of EVs, performance of EVs - traction motor characteristics. Vehicle architecture - electric vehicles, hybrid electric vehicles, plug-in hybrid electric vehicles, power component sizing, vehicle simulation model - forward and reverse simulation model.

MODULE 2 (8 hours)

Vehicle Mechanics

Vehicle mechanics - roadway fundamentals, laws of motion, vehicle kinetics, dynamics of vehicle motion, propulsion power-force velocity characteristics, maximum gradability, velocity and acceleration, tyre-road mechanics - slip, tractive force, force transmission, quarter car model, traction limit and control, propulsion system design.

MODULE 3 (8 hours)

Electric Propulsion Systems

Electric drive components, DC motor drives - two-quadrant chopper, open loop drive, operating point analysis. AC drives - induction machine vector control, six-step operations, pulse width modulation. PMSM drives - current and voltage controllers. Permanent magnet BLDC motor drives - properties of PM materials, control of BLDC motor drives, sensorless techniques. SRM drives - drive converters, modes of operation, sensorless control.

MODULE 4 (7 hours)

Vehicle Controllers and Communication

Vehicle controllers - microcontroller types, components, controller software development - AUTOSAR, software development tools, controller implementation, motor controller. Vehicle communications - OSI seven-layer model, controller area network - CAN transfer protocol, transfer layer, message frames.

MODULE 5 (6 hours)

Autonomous Vehicles and Energy Storage

Levels of autonomous driving, autonomous vehicle architecture- sensors, external communication, software stack-perception, localization, path planning, autopilots and actuators-

throttle by wire, steer by wire, brake by wire, safety enhancements-cruise control, lane control, traction control, automatic braking. Introduction to energy storage, traction batteries types, electric vehicle charging systems.

Text Books

1. Iqbal Hussein, *Electric and Hybrid Vehicles:Design Fundamentals*, CRC Press, 2nd ed., 2010.
2. M.Ehsani,Y.Gao,A.Emadi, *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles*, CRC Press, 2nd ed., 2010.
3. K Sundareswaran R. A, *Elementary Concepts of Power Electronic Drives*, CRC Press, Taylor & Francis Group.

Reference Books

1. James Larminie, John Lowry, *Electric Vehicle Technology Explained*, 2nd ed., Wiley.
2. Per Enge, Nick Enge, Stephen Zoepf *Electric Vehicle Engineering*, 1st ed., McGraw Hill, 2021.
3. Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen, *Electric Vehicles Modern Technologies and Trends*, Springer, 2021.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Electric Vehicles	7
1.1	Need for electric vehicle, configuration of EVs	1
1.2	Performance of EVs - traction motor characteristics	1
1.3	Vehicle architecture - electric vehicles	1
1.4	Hybrid electric vehicles, plug-in hybrid electric vehicles	1
1.5	Plug-in hybrid electric vehicle	1
1.6	Power component sizing - electric vehicle	1
1.7	Vehicle simulation model-forward and reverse simulation model.	1
	Module 2: Vehicle Mechanics	8
2.1	Vehicle mechanics - roadway fundamentals	1
2.2	Laws of motion	1
2.3	Vehicle kinetics	1
2.4	Dynamics of vehicle motion	1

2.5	Propulsion power	1
2.6	Velocity and acceleration	1
2.7	Tyre-road mechanics	1
2.8	Propulsion system design	1
	Module 3: Electric Propulsion Systems	8
3.1	Electric drive components, DC motor drives –two-quadrant chopper	1
3.2	Open loop drive, operating point analysis	1
3.3	AC drives-six step operations, pulse width modulation	1
3.4	Induction machine vector control	1
3.5	PMSM drives-current and voltage controllers	1
3.6	Properties of PM materials, control of BLDC motor drives, sensorless techniques	1
3.7	SRM drives-drive converters, modes of operation	1
3.8	Sensorless control	1
	Module 4: Vehicle Controllers and Communication	7
4.1	Vehicle controllers - microcontroller types	1
4.2	Components, controller software development	1
4.3	AUTOSAR, software development tools	1
4.4	Controller implementation, motor controller	1
4.5	Vehicle communications - OSI seven-layer mode	
4.6	Controller area network - CAN transfer protocol	1
4.7	Transfer layer, message frames	1
	Module 5: Autonomous Vehicles and Energy Storage	6
5.1	Levels of autonomous driving	1
5.2	Autonomous vehicle architecture-sensors, external communication	1
5.3	Software stack, autopilots and actuators, safety enhancements.	1
5.4	Introduction to energy storage	1
5.5	Traction batteries types	1
5.6	Electric vehicle charging systems.	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain vehicle architecture.
2. Classify types of electric vehicles.
3. Discuss vehicle simulation model.

Course Outcome 2 (CO 2)

1. Explain the laws of motion.
2. Describe dynamics of vehicle motion.
3. Discuss the tyre-road mechanic for vehicle mechanics.

Course Outcome 3 (CO 3)

1. Explain the block diagram of electric drive.
2. Explain the construction of BLDC machine.
3. Discuss the various modes of SRM drive.

Course Outcome 4 (CO 4)

1. Identify various microcontroller types used in EVs.
2. Explain CAN transfer protocol.
3. Explain the role of AUTOSAR.

Course Outcome 5 (CO 5)

1. Classify various levels of autonomous driving.
2. Explain the types of traction batteries.
3. Describe the components of vehicle charging systems.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EE4P32

Course Name: : ELECTRIC VEHICLE TECHNOLOGY

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. List the reasons that highlight the need for electric vehicles.
2. Illustrate the block diagram of vehicle simulation model.
3. State laws of motion with relevance to vehicle mechanics.
4. Define tractive force and resistive forces acting on a moving vehicle.
5. Explain the block diagram of an electric drive.
6. List out the properties of PM materials.
7. List out the components used in the vehicle controller for electric vehicles.
8. Explain the significance of CAN used in electric vehicle.
9. Classify the various levels of autonomous driving system.
10. Illustrate the block diagram of electric vehicle charging system.

PART B

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

11. Explain in detail the various configurations of Electric Vehicles and discuss the characteristics of traction motors.

OR

12. Explain in detail the vehicle architecture of Electric Vehicles.
13. Explain the dynamics of vehicle motion under acceleration and deceleration. Discuss load transfer, stability, and traction limitations.

OR

14. Explain tyre-road interaction in detail. Discuss adhesion, slip, rolling radius, traction characteristics, and their effect on vehicle performance.
15. Explain the operation of a two-quadrant chopper drive for DC motor with neat circuit diagram and waveforms. Discuss motoring and regenerative braking modes.

OR

16. Discuss sensorless control techniques in BLDC drives using back-EMF detection and observer-based methods. Discuss advantages in EV applications.
17. Explain in detail about vehicle controllers and their types.

OR

18. Explain in detail about the communication system adopted in electric vehicles.
19. Explain the working of an autopilot system in autonomous vehicles. Discuss steering, braking, and throttle actuation mechanisms.

OR

20. Discuss AC charging and DC fast charging systems in EVs. Explain charging levels, standards, and charging infrastructure requirements.

B24EE4P33	POWER QUALITY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The course aims to impart a comprehensive understanding of power quality issues in electrical power systems and their impact on equipment and system performance. It covers power quality disturbances, harmonics, standards, monitoring techniques, and mitigation methods, including filters and power quality conditioners. By the end of the course, students will be able to analyse power quality problems and apply suitable corrective measures to enhance power system reliability and efficiency.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand various power quality phenomena, their sources, classifications, and effects on electrical power systems and consumer equipment. (Cognitive Knowledge Level: Understand)
CO 2	Explain the mechanisms of harmonic generation, sources of harmonics, including triplen harmonics, power quality indices and analyse their effects on power system components such as transformers, motors, capacitor banks, and communication systems. (Cognitive Knowledge Level: Apply)
CO 3	Understand and analyze electromagnetic interference (EMI) and electrostatic discharge (ESD) phenomena, including their sources, effects, and protection techniques. (Cognitive Knowledge Level: Understand)
CO 4	Understand suitable mitigation techniques, such as passive and active filters, to reduce power quality disturbances. (Cognitive Knowledge Level: Understand)
CO 5	Understand power quality conditioners, correction methods, power quality issues in grid-connected renewable energy systems, and effective grounding and wiring practices. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	20	40	20
Understand	40	60	40
Apply	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 (6 hours)

Power Quality

Power quality phenomenon - sources, effects of power quality problems, need for concern of power quality. Types of power quality disturbances - transients, classification and origin, short duration voltage variation - interruption, sag, swell, long duration voltage variation, voltage unbalance, waveform distortion - notching, harmonics and voltage flicker.

MODULE 2 (9 hours)

Harmonics

Harmonics - mechanism of harmonic generation, triplen harmonics, harmonic sources - switching devices, arcing devices and saturable devices, effects of harmonics on power system equipment and loads - transformers, capacitor banks, motors and telecommunication systems. Harmonic indices (CF, DF, THD, TDD, TIF, DIN, C - message weights), displacement and total power factor, numerical problems. Overview of power quality standards - IEEE 519, IEEE 1433, IEC 61000.

MODULE 3 (7 hours)

Electromagnetic Interference and Electrostatic Discharge (ESD)

Electromagnetic Interferences (EMI) - introduction, frequency classification, electric and magnetic fields, common EMI terminologies, power and high frequency fields. Electrostatic Discharge (ESD) - static generation, human body model, ESD protection in equipment design, transient and surge protection devices.

MODULE 4 (7 hours)

Power Quality Monitoring and Mitigation

Power quality Monitoring - objectives and measurement issues, different monitoring instruments - power quality analyser, harmonic spectrum analyser, flicker meter, disturbance analyser. Mitigation of power quality problems - harmonic elimination, analysis of passive filters to reduce harmonic distortion, demerits of passive filters, description of active filters - shunt, series, hybrid filters.

MODULE 5 (7 hours)

Power Quality Conditioning

Power quality conditioners - DVR, DSTATCOM, UPQC - configuration and working. Power factor correction - single-phase active power factor converter, circuit schematic and control

block diagram. Power quality issues of grid-connected renewable energy systems - operating conflicts, grounding and wiring - reasons for grounding, common issues and solutions.

Text Books

1. Mahesh Kumar Mishra, *Power Quality in Power Distribution Systems: Concepts and Applications*, CRC Press, Taylor & Francis, 1st ed., 2024.
2. Sarath Perera and Sean Elphick, *Applied Power Quality: Analysis, Modelling, Design and Implementation of Power Quality Monitoring Systems*, Elsevier/Academic Press, 1st ed., 2022.
3. R. C. Dugan, M. F. Me Granaghen, and H. W. Beaty, *Electrical Power System Quality*, McGraw-Hill, 3rd ed., 2012.
4. Angelo Baggini (Ed.), *Handbook of Power Quality*, Wiley, 1st ed., 2008.
5. C. Sankaran, *Power Quality*, CRC Press, 1st ed., 2002.

Reference Books

1. P. Sanjeevikumar and C. Sharmela, et al., *Power Quality in Modern Power Systems*, Academic Press, 1st ed., 2020.
2. Ewald F. Fuchs and Mohammad S. Masoum, *Power Quality in Power Systems and Electrical Machines*, Academic Press, 2nd ed., 2015.
3. Bhim Singh, Ambrish Chandra and Kamal Al-Haddad, *Power Quality Problems and Mitigation Techniques*, John Wiley and Sons Ltd, 1st ed., 2015.
4. Jose Arillaga and Neville R. Watson, *Power System Harmonics*, Wiley, 2nd ed., 2004.
5. Surajit Chattopadhyay, *Electric power quality*, Springer, 1st ed., 2011.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Power Quality	6
1.1	Power quality phenomenon - sources, effects of power quality problems, Need for concern of power quality.	2
1.2	Types of power quality disturbances - Transients, classification and origin.	1
1.3	Short duration voltage variation - interruption, sag, swell.	1
1.4	Long duration voltage variation, voltage unbalance, waveform distortion - notching, harmonics and voltage flicker.	2
	Module 2: Harmonics	9
2.1	Harmonics - mechanism of harmonic generation, Triplen harmonics.	2
2.2	Harmonic sources - switching devices, arcing devices and saturable devices.	2
2.3	Effects of harmonics on power system equipment and loads - transformers, capacitor banks, motors and telecommunication systems.	2
2.4	Harmonic indices (CF, DF, THD, TDD, TIF, DIN, C - message weights) numerical problems.	2
2.5	Overview of power quality standards - IEEE 519, IEEE 1433, IEC 61000.	1
	Module 3: Electromagnetic Interference and Electrostatic Discharge (ESD)	7
3.1	Electromagnetic Interferences (EMI)- introduction, frequency classification.	2
3.2	Electric and magnetic fields, common EMI terminologies, power and high frequency fields.	2
3.3	Electrostatic Discharge (ESD) - static generation, human body model.	1
3.4	ESD protection in equipment design, transient and surge protection devices.	2
	Module 4: Power Quality Monitoring and Mitigation	7
4.1	Power quality Monitoring- Objectives and measurement issues.	1
4.2	Different monitoring instruments - Power quality analyzer, harmonic spectrum analyzer, flicker meter, disturbance analyzer.	2
4.3	Mitigation of Power quality problems - Harmonic elimination.	1
4.4	Analysis of passive filters to reduce harmonic distortion, demerits of passive filters.	2

4.5	Description of active filters - shunt, series, hybrid filters.	1
	Module 5: Power Quality Conditioning	7
5.1	Power quality conditioners - DVR, DSTATCOM, UPQC - configuration and working.	2
5.2	Power factor correction - Single phase active power factor converter, circuit schematic and control block diagram.	2
5.3	Power Quality issues of Grid connected Renewable Energy Systems - operating conflicts.	2
5.4	Grounding and wiring- reasons for grounding, common issues and solutions.	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain different types of power quality disturbances.
2. Differentiate between short-duration and long-duration voltage variations with suitable examples.
3. Explain the possible causes and suggest methods to mitigate frequent voltage sag and flicker.

Course Outcome 2 (CO 2)

1. Explain the mechanism of harmonic generation in power systems.
2. What are triplen harmonics? Explain their effect on neutral current and three-phase systems with relevant analysis.
3. Discuss the impact of harmonics on transformers, capacitor banks, motors, and communication systems.

Course Outcome 3 (CO 3)

1. Explain the sources and classification of electromagnetic interference (EMI) in electronic systems.
2. Differentiate between electric and magnetic field coupling in EMI with suitable examples.
3. Illustrate various ESD protection techniques used in electronic equipment design.

Course Outcome 4 (CO 4)

1. Explain the objectives of power quality monitoring.
2. Describe the working of different power quality monitoring instruments.
3. Design a passive filter for harmonic mitigation and discuss its advantages and limitations.

Course Outcome 5 (CO 5)

1. Explain the configuration and working of DVR, DSTATCOM, and UPQC.
2. Describe the working of a single-phase active power factor correction converter with circuit diagram and control strategy.
3. Discuss power quality issues in grid-connected renewable energy systems.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EE4P33

Course Name: : POWER QUALITY

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define power quality and list any two power quality problems.
2. What are voltage sags and swells?
3. What is Total Harmonic Distortion (THD)?
4. What are harmonics? Give two sources of harmonics.
5. Define electromagnetic interference (EMI).
6. State the need for ESD protection in electronic design.
7. Differentiate between shunt and series active filters.
8. List any two power quality monitoring instruments.
9. Describe the term Ground Loops. List solutions for mitigating this problem.
10. Expand DVR and UPQC.

PART B

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

11. (a) Explain different types of power quality disturbances with causes and effects. (8 marks)
(b) Discuss voltage unbalance and waveform distortion with examples. (6 marks)

OR

12. (a) Classify transients and explain their origin in power systems. (7 marks)
(b) Explain short-duration and long-duration voltage variations with suitable waveforms. (7 marks)
13. (a) Explain the mechanism of harmonic generation in power systems. (7 marks)
(b) Discuss the effects of harmonics on transformers and capacitor banks. (7 marks)

OR

14. (a) Explain triplen harmonics and their effect on neutral current. (7 marks)
(b) Discuss various harmonic sources such as switching, arcing, and saturable devices. (7 marks)
15. (a) Describe the Human Body Model (HBM) and other ESD models used for evaluating device susceptibility. (7 marks)
(b) Explain different transient and surge protection devices and their working principles. (7 marks)

OR

16. (a) Describe common EMI terminologies and analyze the impact of power frequency and high-frequency fields on circuit performance. (8 marks)
(b) Discuss electric and magnetic field coupling mechanisms in EMI with suitable diagrams and examples. (6 marks)
17. (a) Explain objectives and issues in power quality monitoring. (7 marks)
(b) Describe working of power quality analyzer and flicker meter. (7 marks)

OR

18. (a) Explain passive filters and their role in harmonic mitigation. (7 marks)
(b) Describe shunt and series active filters with their advantages. (7 marks)
19. (a) Explain configuration and operation of DSTATCOM. (6 marks)
(b) Discuss power quality issues in grid-connected renewable energy systems. (8 marks)

OR

20. (a) Describe single-phase active power factor correction converter and its control. (8 marks)
(b) Discuss the important solutions to wiring and grounding problems. (6 marks)

B24EE4P34	INTERNET OF THINGS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces students to the concepts, architectures, and enabling technologies of the Internet of Things. The syllabus covers IoT fundamentals, data and device processing, connectivity and communication protocols, cloud and fog computing, and representative application case studies. On successful completion, students will be able to understand IoT requirements, select appropriate technologies, and apply IoT solutions to real-world problem domains.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain IoT concepts, architecture, and platforms to support basic IoT system design and prototyping. (Cognitive Knowledge Level: Understand)
CO 2	Understand IoT data processing, gateways, and topologies to support efficient distributed IoT deployments. (Cognitive Knowledge Level: Understand)
CO 3	Explain IoT connectivity technologies to select suitable communication methods for IoT applications. (Cognitive Knowledge Level: Understand)
CO 4	Apply various communication protocols and cloud–fog models to develop scalable IoT solutions. (Cognitive Knowledge Level: Apply)
CO 5	Apply IoT technologies to analyze real-world applications in agriculture, health-care, energy, and industry. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	40	20	20
Understand	60	40	40
Apply		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 (6 hours)

Introduction to IoT

Definition and characteristics of IoT, architectural view, major components and technologies in IoT systems - hardware, software, communication, APIs. Embedded computing - software types, microcontroller based prototyping platforms - IDE, examples, selection factors. IoT and M2M - differences. Success factors of IoT.

MODULE 2 (7 hours)

Data and Device Processing Topologies and Types

Data formats, importance of processing in IoT, six levelled OSI model for IoT, gateways - data and device management functions, processing topologies - on site and off site, IoT device selection and considerations, Processing offloading - location, decision making, offloading considerations.

MODULE 3 (8 hours)

Connectivity Technologies for IoT

Wireless connectivity - RFID, NFC, Zigbee, Bluetooth/Bluetooth LE, Wifi (IEEE 802.11), cellular technology - GSM, 3G, 4GLTE, LoRa technology - LoRaWAN, Narrow Band (NB-IoT), Sigfox. (overview, features, applications, limitations.)

Wired connectivity - UART / USART serial communication, serial peripheral interface, I2C Bus, wired USB, ethernet.

MODULE 4 (9 hours)

IoT Communication Technologies

Concept of constrained networks and low power and lossy networks (LLNs), infrastructure protocols - IPv4, IPv6, RPL, 6LoWPAN. Data protocols - MQTT, CoAP, REST, SOAP. Identification protocols - EPC, uCode, URI. (concept only).

Cloud Computing

Virtualization - advantages, types. Cloud service and deployment models. Cloud implementation - simulators. Features of any commercial cloud service. Sensor clouds - architecture. Fog computing - characteristics and comparison with cloud computing.

MODULE 5 (6 hours)

Applications/Case Studies of IoT Technology

Agricultural IoT - components, advantages, case studies. IoT in healthcare - architecture, components, advantages, risks. Vehicular IoT - components, advantages, applications. IoT in environment monitoring – weather and air pollution monitoring. IoT in energy management, smart metering. Industrial IoT.

Text Books

1. Raj Kamal, *Internet of Things: Architecture and Design Principles*, McGraw-Hill (India) Private Limited, 1st ed., 2017.
2. Sudip Misra, Anandarup Mukherjee, Arijit Roy *Introduction to IoT*, Cambridge University Press, 1st ed., 2021.
3. Vijay Madiseti and Arshdeep Bahga, *Internet of Things (A Hands on-Approach)*, Orient Blackswan Private Limited -New Delhi, 1st ed., 2015.

References

1. Simone Cirani, *Internet of Things: Architecture, Protocols and Standards*, Wiley, 1st ed., 2019.
2. Qusay F. Hassan, *Internet of Things A to Z: Technologies and Applications*, IEEE Press, 1st ed., 2018.
3. Al-Fuqaha et al., *Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications*, IEEE Communications Surveys & Tutorials, 2015.
4. Alasdair Gilchrist, *Industry 4.0: The Industrial Internet of Things*, Apress, 2016.
5. O. Munoz et al., *Development of an IoT Smart Energy Meter with Power Quality Features for a Smart Grid Architecture*, Sustain. Comput. Informatics Syst., vol. 43, p. 100990, 2024, doi: 10.1016/j.suscom.2024.100990.
6. P. Pandiyan et al., *A Comprehensive Review of Advancements in Green IoT for Smart Grids: Paving the Path to Sustainability*, Energy Reports, vol. 11, pp. 5504–5531, 2024, doi: 10.1016/j.egy.2024.05.021.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to IoT	6
1.1	Definition and characteristics of IoT	1

1.2	IoT architectural view	1
1.3	Major components: hardware, software and middleware	1
1.4	Communication modules and APIs	1
1.5	Embedded computing: software types, microcontroller platforms and IDEs	1
1.6	Platform selection factors, IoT vs M2M, success factors of IoT	1
	Module 2: Data and Device Processing	7
2.1	Data formats in IoT and importance of data processing	1
2.2	Six-layered OSI model for IoT	1
2.3	Gateways: architecture and data management functions	1
2.4	Gateways: device management functions	1
2.5	Processing topologies: on-site and off-site processing	1
2.6	IoT device selection and considerations	1
2.7	Processing offloading: location, decision making and considerations	1
	Module 3: Connectivity Technologies for IoT	8
3.1	Introduction to IoT connectivity and classification	1
3.2	RFID and NFC: features, applications and limitations	1
3.3	Zigbee and Bluetooth/BLE	1
3.4	Wi-Fi (IEEE 802.11)	1
3.5	Cellular technologies: GSM, 3G, 4G LTE	1
3.6	LoRa and LoRaWAN, NB-IoT and Sigfox	1
3.7	Wired communication: UART, SPI, I2C, USB, Ethernet	2
	Module 4: IoT Communication and Cloud Computing	9
4.1	Constrained networks and low power and lossy networks (LLNs)	1
4.2	Infrastructure protocols: IPv4 and IPv6	1
4.3	RPL and 6LoWPAN (concepts)	1
4.4	Data protocols: MQTT, CoAP, REST and SOAP (comparison and use cases)	2
4.5	Identification protocols: EPC, uCode, URI	1
4.6	Virtualization: concepts, advantages and types	1
4.7	Cloud service models and deployment models	1
4.8	Cloud implementation, sensor cloud architecture, fog vs cloud computing	1
	Module 5: Applications/Case Studies of IoT Technology	6
5.1	Agricultural IoT: components and advantages	1
5.2	Agricultural IoT case studies	1
5.3	IoT in healthcare: architecture, components, risks	1
5.4	Vehicular IoT: components and applications	1
5.5	Environmental monitoring: weather and air pollution monitoring	1
5.6	IoT in energy management, smart metering and industrial IoT	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Define Internet of Things (IoT).
2. What are the main layers of IoT architecture?
3. Describe the features of an IoT prototyping platform.

Course Outcome 2 (CO 2)

1. What is an IoT gateway?
2. What is meant by on-site and off-site processing?
3. Discuss any two data formats used in IoT.

Course Outcome 3 (CO 3)

1. Classify IoT communication technologies into short-range and long-range with examples.
2. Describe any two wired communication technologies used in IoT.
3. What is the significance of I2C communication?

Course Outcome 4 (CO 4)

1. Which protocol is used for publish-subscribe communication in IoT?
2. When would you use fog computing instead of cloud computing?
3. State the importance of URI.

Course Outcome 5 (CO 5)

1. Describe an example of IoT in agriculture.
2. How is IoT used in healthcare?
3. What is smart metering?

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EE4P34

Course Name: : INTERNET OF THINGS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Compare M2M with IoT.
2. Discuss the success factors of IoT.
3. Differentiate structured and unstructured data in the context of IoT.
4. What are the types of data based on urgency? Give examples for each.
5. Draw the various topologies in Zigbee communication.
6. What are the components required in an RFID system, and the role of each.
7. Mention at least six types of messages in MQTT and its purpose.
8. Give example of any commercial cloud and mention at least six of its features.
9. Mention the tasks of an air pollution monitoring system.
10. Mention at least three features of energy management system in smart grids.

PART B

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

11. Draw and explain the architectural view of an IoT system as suggested by Oracle. (14 Marks)

OR

12. (a) Discuss the types of embedded software. (6 Marks)
(b) With the help of a schematic diagram, explain functional and application-specific units of a typical microcontroller unit. (8 Marks)
13. Discuss device management protocols – TR-069 and OMA-DM. (14 Marks)

OR

14. Discuss seven factors governing the IoT device design and selection. (14 Marks)
15. Explain the architecture and implementation of LoRa wireless communication technology. (14 Marks)

OR

16. Discuss the features of the following wired connectivity protocols: UART, I2C, Wired USB. (14 Marks)
17. Give the architectural diagrams of a WSN implemented in the traditional way as well as using a sensor cloud platform. Explain how the sensor cloud based approach is advantageous. (14 Marks)

OR

18. Discuss the features and addressing in IPv6. How is it different from IPv4? (14 Marks)
19. Give the components needed in a farm based agricultural IoT system and explain the role of each. (14 Marks)

OR

20. Draw and describe the architecture of a healthcare IoT system and briefly explain the components required for its implementation. (14 Marks)

B24EE4P35	SOLID STATE DEVICES	L	T	P	S	HOURS	CREDIT
		2	1	0	4	3	3

Preamble

This course aims to impart fundamental knowledge on solid-state physics and the operating principles of semiconductor devices. It provides a sound understanding of modern semiconductor devices and their fabrication technology to enable students to appreciate their applications in electronic circuits and systems. By the end of the course, students will possess the theoretical knowledge required to select solid-state devices for various engineering applications and environments.

Prerequisites

Engineering Physics, Electronic Circuits I

Course Outcomes

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

CO 1	Apply the basic laws of solid-state physics to understand the properties of semiconductor materials. (Cognitive Knowledge Level: Understand)
CO 2	Understand the generation, recombination, diffusion, and transport of excess carriers in semiconductors. (Cognitive Knowledge Level: Understand)
CO 3	Analyze the electrical behaviour of MOS structures through energy band diagrams, depletion layer properties, and capacitance–voltage characteristics under various conditions and to understand the role of CMOS technology in modern semiconductor devices. (Cognitive Knowledge Level: Apply)
CO 4	Analyze the structure and operation of Silicon Carbide devices like Silicon Carbide BJT, Silicon Carbide MOSFET and Silicon Carbide IGBT. (Cognitive Knowledge Level: Understand)
CO 5	Describe the structure and operating principles of vertical and lateral GaN HFETs and explain the operating principles, performance characteristics of specialized semiconductor devices. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	2	1	1	1		1					1
CO 2	2	1	1	1		1					1
CO 3	2	1	1	1		1					1
CO 4	2	1	1	1		1					1
CO 5	1	1	1	1		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	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 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 sub-divisions.

SYLLABUS

MODULE 1 (7 hours)

Energy Bands and Charge Carriers in Semiconductors

Bonding forces and energy bands in solids - bonding forces in solids, energy bands, metals, semiconductors, and insulators, direct and indirect semiconductors, variation of energy bands with alloy composition. Drift of carriers in electric and magnetic fields - conductivity and mobility, drift and resistance, effects of temperature and doping on mobility, high-field effects, Hall effect.

MODULE 2 (8 hours)

Excess Carriers in Semiconductors

Carrier concentrations - the Fermi level, electron and hole concentrations at equilibrium, invariance of the Fermi level at equilibrium, optical absorption, luminescence - photoluminescence, electroluminescence, carrier lifetime and photoconductivity - direct recombination of electrons and holes, indirect recombination, steady state carrier generation, quasi-Fermi levels - gradients in the quasi-Fermi levels. Generation and recombination mechanisms of excess carriers - diffusion of carriers - diffusion processes, diffusion and drift of carriers, diffusion and recombination, steady state carrier injection, Haynes-Shockley experiment.

MODULE 3 (7 hours)

Metal Oxide Semiconductor Field Effect Transistors

Two terminal MOS structure - energy band diagrams, depletion layer thickness, surface charge density, work function differences, flat band voltage, capacitance, voltage characteristics-ideal characteristics, frequency effects, fixed oxide and interface charge effects, Frequency limitations - small signal equivalent circuit, frequency limitation factors, cutoff frequency, CMOS technology.

MODULE 4 (6 hours)

Silicon Carbide Devices

Silicon Carbide BJT - structure, operation, static and dynamic characteristics. Silicon Carbide MOSFET - planar power MOSFETs, trench gate power MOSFETs - structure, static and dynamic characteristics. Silicon Carbide IGBT: n-Channel asymmetric structure, optimized n-channel asymmetric structure, p-channel asymmetric structure, blocking characteristics, on-state voltage drop, turn-off characteristics, switching energy, losses, maximum operating frequency.

MODULE 5 (8 hours)

Gallium Nitride Devices

Vertical power hetero junction field effect transistor (HFETs) - lateral power hetero junction - field effect transistor, high electron mobility transistors (HEMT) - static and dynamic characteristics, GaN MIS HFETs, GaN MESFETs.

Specialized Semiconductor Devices

Heterojunction solar cell, amorphous silicon solar cell, laser diodes - stimulated emission and population inversion, optical cavity, device structures and characteristics.

Text Books

1. Ben G. Streetman and Sanjay Kumar Banerjee, *Solid State Electronic Devices*, Pearson, 6th ed., 2010.
2. Donald A. Neamen, *Semiconductor Physics and Devices*, McGraw Hill, 4th ed., 2012.
3. Sze S.M., *Physics of Semiconductor Devices*, John Wiley, 3rd ed., 2005.
4. Kazuhiro Mochizuki, *Vertical GaN and SiC Power Devices*, Artech House, 2018..

Reference Books

1. Tyagi M.S., *Introduction to Semiconductor Materials and Devices*, Wiley India, 5th edition, 2008.
2. Pierret, *Semiconductor Devices Fundamentals*, Pearson, 1st edition, 2006.
3. Rita John, *Solid State Devices*, McGraw-Hill, 1st edition, 2014.
4. Bhattacharya Sharma, *Solid State Electronic Devices*, Oxford University Press, 2nd edition, 2012.
5. Dasgupta and Dasgupta, *Semiconductor Devices: Modelling and Technology* (PHI), 1st edition, 2013.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Energy Bands and Charge Carriers in Semiconductors	7

1.1	Bonding forces and energy bands in solids – bonding forces in solids, energy bands, metals, semiconductors, and insulators	1
1.2	Direct and indirect semiconductors, variation of energy bands with alloy composition	1
1.3	Drift of carriers in electric and magnetic fields	1
1.4	Conductivity and mobility	1
1.5	Drift and resistance, effects of temperature and doping on mobility	2
1.6	High-field effects, Hall effect	1
	Module 2: Excess Carriers in Semiconductors	8
2.1	Carrier concentrations – the Fermi level, electron and hole concentrations at equilibrium	1
2.2	Luminescence – photoluminescence, electroluminescence, optical absorption	1
2.3	Carrier lifetime and photoconductivity – direct recombination of electrons and holes, indirect recombination	1
2.4	Steady state carrier generation	1
2.5	Invariance of the Fermi level at equilibrium, Quasi-Fermi levels – gradients in the quasi-Fermi levels	1
2.6	Generation and recombination mechanisms of excess carriers	1
2.7	Diffusion of carriers – diffusion processes, diffusion and drift of carriers, diffusion and recombination, steady state carrier injection, Haynes-Shockley experiment	2
	Module 3: Metal Oxide Semiconductor Field Effect Transistors	7
3.1	Two terminal MOS structure - energy band diagrams, depletion layer thickness	1
3.2	Surface charge density, work function differences	1
3.3	Flat band voltage, capacitance, Voltage characteristics-ideal characteristics	1
3.4	Frequency effects, fixed oxide and interface charge effects	1
3.5	Frequency limitations - small signal equivalent circuit	1
3.6	Frequency limitation factors, cutoff frequency	1
3.7	CMOS technology	1
	Module 4: Silicon Carbide Devices	6
4.1	Silicon Carbide BJT - structure, operation, static and dynamic characteristics.	1
4.2	Silicon Carbide MOSFET - planar power MOSFETs	1
4.3	Trench gate power MOSFETs - structure, static and dynamic characteristics.	1
4.4	Silicon Carbide IGBT: n-Channel asymmetric structure, optimized n-channel asymmetric structure	1
4.5	P-channel asymmetric structure, blocking characteristics, on-state voltage drop	1

4.6	Turn-off characteristics, switching energy, losses, maximum operating frequency	1
	Module 5: Gallium Nitride Devices and Specialized Semiconductor Devices	8
5.1	Vertical Power Hetero Junction Field Effect Transistor (HFETs)	1
5.2	Lateral Power Hetero Junction – Field Effect Transistor, (HFETs)	1
5.3	High Electron Mobility Transistors (HEMT) - Static and dynamic characteristics	1
5.4	GaN MIS HFETs	1
5.5	GaN MESFETs	1
5.6	Specialized semiconductor devices - heterojunction solar cell, amorphous silicon solar cell	1
5.7	Laser diodes- stimulated emission and population inversion	1
5.8	Optical cavity, device structures and characteristics	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain and compare the types of bonding in solids.
2. Distinguish direct and indirect semiconductor band gaps.
3. Analyze Hall-effect measurements.

Course Outcome 2 (CO 2)

1. Explain optoelectronic mechanisms.
2. Evaluate nonequilibrium states.
3. Analyze the transport and decay of excess carriers.

Course Outcome 3 (CO 3)

1. Analyze MOS electrostatics and band dynamics.
2. Evaluate capacitance-voltage (C-V) characteristics.
3. Model high-frequency performance and CMOS integration.

Course Outcome 4 (CO 4)

1. Explain the material properties of Silicon Carbide.
2. Describe the structure, operation and characteristics of SiC BJT.
3. Select suitable devices for power electronic applications.

Course Outcome 5 (CO 5)

1. Describe the structure and operation of vertical and lateral GaN HFETs.
2. Understand the working of GaN MIS-HFETs and GaN MESFETs.
3. Explain the structure and operation of heterojunction and amorphous silicon solar cells.

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: B24EE4P35

Course Name: SOLID STATE DEVICES

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the energy band structure of a semiconductor with a neat diagram.
2. Explain the effect of temperature on mobility.
3. Draw the Fermi Dirac Distribution function of intrinsic, n-type and p-type semiconductors.
4. Differentiate between photoluminescence and electroluminescence with suitable examples.
5. What is meant by body effect in MOSFET? How does it affect the threshold voltage of the MOSFET?
6. Define cut-off frequency. Explain the frequency limitation factors in MOS devices.
7. Describe the structure of a Silicon Carbide BJT with a neat sketch,
8. Define on-state resistance in SiC MOSFET.
9. List the advantages of GaN HEMTs over conventional FETs.
10. Define stimulated emission and explain its significance in laser operation.

PART B

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

11. (a) Describe the formation of energy bands in solids starting from isolated atoms. Explain how valence band and conduction band are formed. (8 marks)
- (b) Explain the band theory of solids and explain how it accounts for the electrical behavior of different materials. (6 marks)

OR

12. (a) What is Hall Effect? Derive the expression for finding the carrier concentration of a semiconductor from Hall voltage. (8 marks)
- (b) Explain the high-field effects in semiconductors, including velocity saturation and carrier heating. (6 marks)
13. (a) Derive the expression for equilibrium electron and hole concentrations in a semiconductor in terms of the effective density of states. (8 marks)
- (b) Discuss the concept of photoconductivity and explain how illumination affects the conductivity of a semiconductor. (6 marks)

OR

14. (a) Explain the Haynes–Shockley experiment used to determine carrier mobility and diffusion coefficient. (8 marks)
- (b) Describe diffusion process. Derive the expression for diffusion current density. (6 marks)
15. (a) Explain the concepts of velocity saturation and hot carrier effects in a MOSFET. (8 marks)
- (b) What is channel length modulation in MOSFETs? How does it affect the output characteristics of the MOSFET? (6 marks)

OR

16. (a) Derive the expression for the drain current of a MOSFET under linear and saturation regions. (8 marks)
- (b) Find $I_{D(sat)}$ and $g_{m(sat)}$ of an n-channel MOSFET having the following parameters: channel length = $2\ \mu\text{m}$, thickness = $30\ \mu\text{m}$, electron mobility = $450\ \text{cm}^2/\text{V-s}$, threshold voltage = $0.8\ \text{V}$ and $V_{gs} = 4\ \text{V}$. (6 marks)
17. (a) Explain the static and switching characteristics of Silicon Carbide BJT. (8 marks)
- (b) Draw and explain the structure of planar SiC MOSFET. (6 marks)

OR

18. (a) Explain the n-channel asymmetric structure of SiC IGBT. (8 marks)
- (b) Explain the switching and conduction losses in SiC devices. (6 marks)

19. (a) Describe the structure and working of lateral GaN HFET. (8 marks)
(b) Discuss the static characteristics of GaN HEMTs with suitable graphs.(6 marks)

OR

20. (a) Explain the structure and working principle of a heterojunction solar cell and mention its advantages. (8 marks)
(b) Describe the construction and operation of an amorphous silicon solar cell. (6 marks)



B24EE4P36	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	2	3	2024

Preamble

The course aims to introduce the fundamental principles of intelligent systems and the advanced concepts and algorithms in machine learning to students. The course helps to understand the characteristics of intelligent systems, knowledge representation schemes, logic and inference mechanism and decision trees, Bayes algorithm, basic clustering algorithms and performance measures. This course helps the learner to understand the design of Self Study systems and to apply machine learning based solutions to real world problems.

Prerequisites

Linear Algebra and Multivariable Calculus (B24MA1T01)

Course Outcomes

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

CO 1	Understand the foundations, history, applications, and agent-based models of Artificial Intelligence. (Cognitive Knowledge Level: Understand)
CO 2	Apply uninformed and informed search strategies to solve well-defined AI problems. (Cognitive Knowledge Level: Apply)
CO 3	Understand the foundations, history, applications, and agent-based models of Artificial Intelligence. (Cognitive Knowledge Level: Understand)
CO 4	Demonstrate supervised learning concepts. (Cognitive Knowledge Level: Apply)
CO 5	Solve real life problems using appropriate machine learning models and evaluate the performance measures. (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	2	1	3	3		1			2
CO 2	3	2	1	2	3	3		1			2
CO 3	3	2	2	1	3	3		1			2
CO 4	3	2	1	2	3	3		1			2
CO 5	3	2	1	2	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	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 (8 hours)

Intelligent Agents

History of Artificial Intelligence (AI), applications of AI, foundations of AI, AI components, AI architecture, agenting in AI, intelligent agents - agents and its environments. Concept of rationality - performance measures, rationality. Nature of environment - specifying the task environment, properties of task environment. Environment types - observable, deterministic, episodic, static. Agent structure, agent programmes, agent architectures - simple reflex, model-based, goal-based, utility-based agents.

MODULE 2 (8 hours)

Problem Solving by Search

Problem solving agents - problem formulation, search, execution, example problems, real world problems. Search algorithms - best first search, search data structures, redundant paths, measuring problem - solving performance, uninformed search algorithms - breadth first search, depth first search. Informed search algorithms -A* search, AO* search. Heuristic functions, adversarial search - minimax algorithm.

Use python program for implementing artificial intelligence algorithms (Tutorials/Assignment only)

MODULE 3 (7 hours)

Overview of Machine Learning

Basic concepts, introduction to Machine Learning (ML), applications of ML, learning associations, classification - regression, unsupervised learning, reinforcement learning, supervised learning. Learning a class from example.

Parameter Estimation Methods

Maximum Likelihood Estimation (MLE), Bayes Estimator.

MODULE 4 (7 hours)

Decision Tree

Representation, univariate trees - classification trees, regression tree, pruning, rule extraction from trees, learning rules from data, multivariate trees. Clustering - mixture densities, K-

means clustering, supervised learning after clustering, hierarchical clustering, choosing the number of clusters.

Use python program for implementing machine learning algorithms (Tutorials/Assignment only)

MODULE 5 (6 hours)

Performance Measures

Measuring accuracy using cross-validation, confusion matrix, precision, recall, precision/recall trade off, receiver operator characteristic (ROC) curve, multiclass, classification, error analysis, multilabel classification, multioutput classification, linear regression and classification.

Text Books

1. S. Russell, P. Norvig P, *Artificial Intelligence: A Modern Approach*, Pearson Prentice Hall, 4th ed., 2014.
2. D. Poole, A. Mackworth, *Artificial Intelligence: Foundations of Computational Agents*, 2nd ed., 2017.
3. Ethem Alpaydin, *Introduction to Machine Learning*, MIT Press, 2nd ed., 2010.
4. Mohammed J. Zaki, Wagner Meira, *Data Mining and Analysis: Fundamental Concepts and Algorithms*, Cambridge University Press, 1st ed., 2016.
5. Han, J, M. Kamber, *Data Mining: Concepts and Techniques*, 2nd ed., 2006.

Reference Books

1. Luger F. G, *Artificial Intelligence: Structures and Strategies for Complex Problem Solving*, Pearson Education Asia ,6th ed., 2009.
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, *The Elements Of Statistical Learning*, Springer, 2nd ed., 2007.
3. Davy Cielen, Arno DB Meysman, Mohamed Ali, *Introducing Data Science: Big Data, Machine Learning, and More, Using Python Tools*, Dreamtech Press, 1st ed., 2016.
4. Duda, R. O., P. E. Hart, D. G. Stork, *Pattern Classification*, New York: Wiley, 2nd ed., 2001.
5. Ian H Witten, Eibe Frank, Mark A Hall, *Data Mining: Practical Machine Learning Tools and Techniques*, Morgan Kaufmann, 5th ed., 2025.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Intelligent Agents	8
1.1	History of Artificial Intelligence (AI), applications of AI, foundations of AI, AI components	2
1.2	AI architecture, agenting in AI, intelligent agents	2
1.3	Concept of rationality - performance measures, rationality	1
1.4	Nature of environment	1
1.5	Environment types, agent architecture	2
	Module 2: Problem Solving by Search	8
2.1	Problem solving agents - problem formulation, search, execution.	2
2.2	Example problems, real world problems	1
2.3	Search algorithms - best first search, search data structures	1
2.4	Redundant paths, measuring problem solving performance	1
2.5	Uninformed search algorithms, informed search algorithms, heuristic functions	2
2.6	Adversarial search	1
	Module 3: Overview of Machine Learning and Parameter Estimation Methods	7
3.1	Basic concepts, introduction to Machine Learning (ML)	2
3.2	Applications of ML, learning associations	1
3.3	Classification - regression, unsupervised learning, reinforcement learning	1
3.4	Supervised learning, Learning a class from example	1
3.5	Maximum Likelihood Estimation (MLE), Bayes Estimator	2
	Module 4: Decision Tree	7
4.1	Representation, univariate trees - classification trees, regression tree, pruning	2
4.2	Rule extraction from trees, learning rules from data, multivariate trees	2
4.3	Clustering - mixture densities, K-means clustering	1
4.4	Supervised learning after clustering	1
4.5	Hierarchical clustering, choosing the number of clusters	1
	Module 5: Performance Measures	6
5.1	Measuring accuracy using cross-validation	1
5.2	Confusion matrix, precision, recall, precision/recall trade off	1
5.3	Receiver operator characteristic (ROC) curve	1
5.4	Multiclass, classification, error analysis	1
5.5	Multilabel classification, multioutput classification	1
5.6	Linear regression and classification	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain in detail AI architecture.
2. Analyze basic types of agents programs in intelligent systems.
3. Illustrate properties of different task environments.

Course Outcome 2 (CO 2)

1. Differentiate between uninformed and informed search algorithms .
2. Explain about adversarial search.
3. Define heuristic function.

Course Outcome 3 (CO 3)

1. Explain the basic concepts of machine learning.
2. Differentiate between Maximum Likelihood estimation (MLE) and bayes Estimator.
3. Explain the performance measure of search algorithm.

Course Outcome 4 (CO 4)

1. Explain univariate trees.
2. Illustrate the strength and weakness of k-means algorithm.
3. Explain hierarchical clustering in machine learning.

Course Outcome 5 (CO 5)

1. Problems on classifier.
2. Explain the Receiver operator characteristic (ROC) curve.
3. Explain Linear regression and classification.

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EE4P36

Course Name: : ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain rationality in the context of intelligent agents.
2. Differentiate between observable and deterministic environment types.
3. Define heuristic function. Give one example.
4. Differentiate between informed search and uninformed search algorithms.
5. Define supervised learning? Name special cases of supervised learning depending on whether the inputs/outputs are categorical, or continuous.
6. Differentiate between Maximum Likelihood estimation (MLE) and Bayes Estimator.
7. Explain regression tree and pruning.
8. What is K-means clustering.
9. Explain linear regression and classification.
10. Explain an ROC curve.

PART B

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

11. (a) Explain the properties of different task environments and discuss how each property influences the design of intelligent agents with examples. (8 marks)
(b) Explain the concept of rationality in AI. (6 marks)

OR

12. (a) Explain the various agent architectures—simple reflex, model-based, goal-based and utility-based—with suitable diagrams. (8 marks)
(b) Discuss the foundations and history of Artificial Intelligence and explain how these shaped modern AI applications. (6 marks)
13. (a) Explain the problem formulation process for a search -based agent. (7 marks)
(b) Compare uninformed search with informed search. Discuss how heuristic functions affect search performance. (7 marks)

OR

14. Explain the working of BFS, DFS. Compare them using performance measure. (14 marks)
15. Explain the basic concepts of machine learning and discuss the various applications of ML with suitable examples of learning associations. (14 marks)

OR

16. Describe the different types of machine learning classification tasks and explain how supervised learning enables learning a class from example. (14 marks)
17. (a) A patient takes a lab test and the result comes back positive. It is known that the test returns a correct positive result in only 98% of the cases and a correct negative result in only 97% of the cases. Furthermore, only 0.008 of the entire population has this disease.
What is the probability that this patient has cancer?
What is the probability that he does not have cancer?
What is the diagnosis? (9 marks)
(b) Discuss the issues involved in decision tree learning. (5 marks)

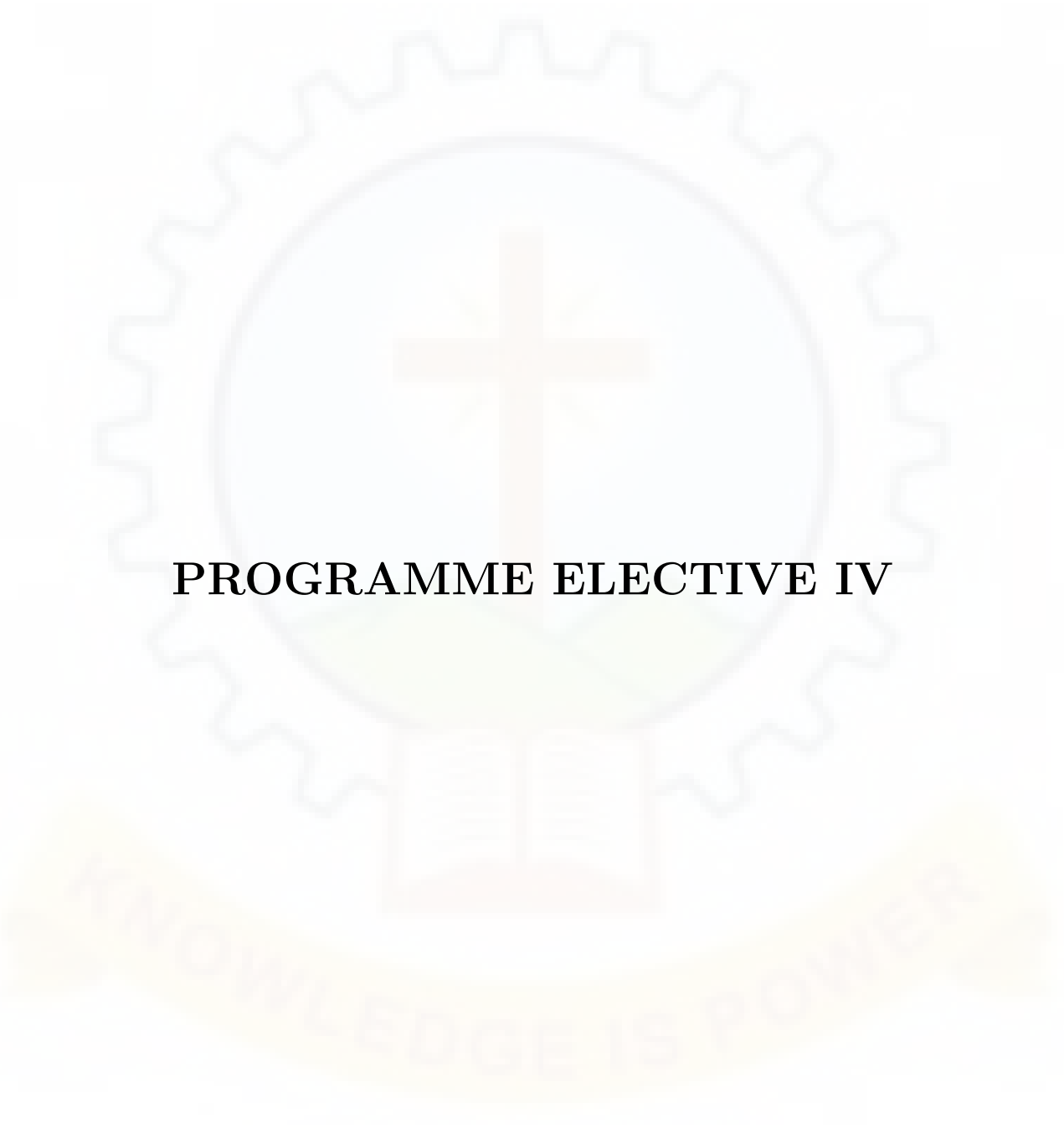
OR

18. (a) Use K Means clustering to cluster the following data into two groups. Assume cluster centroid are $m_1=2$ and $m_2=4$. The distance function used is Euclidean distance.
2, 4, 10, 12, 3, 20, 30, 11, 25 . (9 marks)
(b) Write down the major differences between K- means clustering and hierarchical clustering. (5 marks)

19. (a) Explain how cross validation is used to measure the accuracy of a supervised learning model . (7 marks)
- (b) Describe the steps involved in K fold cross validation and discuss its advantages over a simple train test split. (7 marks)

OR

20. (a) Illustrate how receiver operating characteristics (ROC) curve is constructed and how the area under the curve is interpreted for evaluating model performance. (9 marks)
- (b) Classifier A attains 100% accuracy on the training set and 70% accuracy on the test set. Classifier B attains 70% accuracy on the training set and 75% accuracy on the test set. Which one is a better classifier. Justify your answer. (5 marks)



PROGRAMME ELECTIVE IV

B24EE4P41	DIGITAL CONTROL SYSTEM	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course equips students with the knowledge and analytical skills required to model, analyze, and design digital control systems used in modern engineering applications. Students gain problem-solving ability in stability analysis, time-domain and frequency-domain techniques, and discrete-time state space system design. Upon completion of the course, students will be able to model and design robust digital control systems capable of meeting performance requirements for a wide range of applications .

Prerequisites

Signals and Systems, Linear Control Systems

Course Outcomes

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

CO 1	Develop digital control systems using sampling concepts, s-plane to z-plane mapping, and pulse transfer functions for open and closed-loop systems. (Cognitive Knowledge Level: Apply)
CO 2	Analyze the absolute stability of discrete-time control systems using z-plane. (Cognitive Knowledge Level: Apply)
CO 3	Design lag, lead, and lead-lag compensators for discrete-time systems using root locus and frequency response methods.(Cognitive Knowledge Level: Apply)
CO 4	Model and analyze discrete-time systems using state-space representation, state transition equations, canonical forms, and z-transform solutions. (Cognitive Knowledge Level: Apply)
CO 5	Design state feedback controllers and observers based on controllability and observability criteria, and pole placement techniques. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	25	25	25
Understand	25	25	25
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/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 (7 hours)

Introduction to Digital Control Systems

Basic digital control scheme, comparison between analog and digital control systems, advantages and limitations, sampling theorem, zero-order hold (ZOH) and first-order hold (FOH), mapping between the s-plane and the z-plane.

Pulse Transfer Function

Significance, different configurations for the design - cascaded elements, open loop and closed loop systems, closed loop pulse transfer function.

MODULE 2 (7 hours)

Stability Analysis

Root locus - construction, stability analysis - Jury's test, Schur-Cohn test, bilinear transformation, Routh-Hurwitz method in w-plane, numerical problems.

MODULE 3 (8 hours)

Design of Compensators

Direct design based on root locus - design of lag compensator, lead compensator, and lead-lag compensator. Direct design based on frequency response - design of lag compensator, lead compensator, and lead-lag compensator.

MODULE 4 (8 hours)

Discrete-time State Space System

State variable approach of discrete data system with sample/hold devices - state transition equations, state diagrams, relation between state space representation and pulse transfer function, transformation to canonical forms, solution of state equation - z transform approach, state transition matrix.

MODULE 5 (6 hours)

Design of Discrete-time System in State Space

Controllability and observability of discrete time systems, state controller design via pole

placement, state observer design - full order observer, reduced order observer.

Implementation of a digital control system using DSP/ FPGA processor, (Tutorials/Assignment only)

Text Books

1. K. Ogata, *Discrete-Time Control Systems*, Pearson Education, Asia, 2nd ed., 2010
2. M. Gopal, *Digital Control and State Variable Methods*, Tata McGraw-Hill, 4th ed., 2012
3. C. L. Philips, H. T. Nagle, A Chakraborty, *Digital Control Systems Analysis and Design*, Pearson Education Limited, 3rd ed., 2015.
4. Samanta, *Introduction to Digital Control*, Khanna Publishers, 10th ed., 2008

Reference Books

1. Benjamin C. Kuo, *Digital Control Systems*, Oxford University Press ,3rd ed., 2007
2. Gene F. Franklin, J. David Powell, Michael Workman, *Digital Control of Dynamic Systems*, Pearson, Asia, 6th ed., 2015.
3. M .Sami Fadali ,Antonio Visoli , *Digital Control Engineering*, Academic Press, 1st ed., 2009
4. James R. Leigh, *Applied Digital Control: Theory, Design, and Implementation*, Prentice-Hall, 2nd ed., 2001.
5. Frank L. Lewis, *Applied Optimal Control & Estimation*, Prentice-Hall, 2nd ed., 2009

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Digital Control Systems	7
1.1	Introduction and basic digital control scheme	1
1.2	Comparison between analog and digital control systems, advantages and limitations	1
1.3	Sampling theorem, zero-order hold (ZOH) and first-order hold (FOH), mapping between the s-plane and the z-plane.	1
	Pulse Transfer Function	

1.4	Pulse Transfer Function -Significance	1
1.5	Different configurations for the design - cascaded elements, open loop and closed loop systems	2
1.6	Closed loop pulse transfer function.	1
	Module 2: Stability Analysis	7
2.1	Root locus - construction	1
2.2	Stability analysis.	1
2.3	Jury's test, Schur-Cohn test, Numerical problems.	2
2.4	Bilinear transformation	1
2.5	Routh-Hurwitz method in w-plane.	1
2.6	Numerical problems	1
	Module 3: Design of Compensators	8
3.1	Direct design based on root locus	1
3.2	Numerical problems	1
3.3	Design of lag compensator	1
3.4	Numerical problems	1
3.5	Design of lead compensator	1
3.6	Numerical problems	1
3.7	Design of lead-lag compensator, direct design based on frequency response - design of lag compensator	1
3.8	Design of lag compensator, lead compensator, and lead-lag compensator.	1
	Module 4: Discrete-time State Space System	8
4.1	State variable approach of discrete data system with sample/hold devices	1
4.2	State transition equations, state diagrams	2
4.3	Relation between state space representation and pulse transfer function	1
4.4	Transformation to canonical forms	1
4.5	Solution of state equation	1
4.6	Z transform approach	1
4.7	State transition matrix .	1
	Module 5: Design of Discrete-time System in State Space	6
5.1	Controllability and observability of discrete time systems	2
5.2	State controller design via pole placement	1
5.3	State observer design	1
5.4	Full order observer	1
5.5	Reduced order observer	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Compare between analog and digital control systems.

2. Distinguish between ZOH and FOH
3. Give mapping guidelines for mapping from s plane to z plane.

Course Outcome 2 (CO 2)

1. Problems based on Jury's test for stability analysis.
2. Describe the Bilinear Transformation and its application in mapping the s-plane to the z-plane .
3. Analyze Routh-Hurwitz method for stability analysis

Course Outcome 3 (CO 3)

1. What are the advantages of using the root locus method for compensator design in digital control systems?.
2. Identify the key characteristics of a lead compensator for digital systems in root locus approach .
3. Using Bode diagram concepts, explain how a digital lag compensator improves steady-state accuracy.

Course Outcome 4 (CO 4)

1. Analyse the state-space approach in discrete control system design?
2. Problems based on state transition equations .
3. What is state transition matrix ?

Course Outcome 5 (CO 5)

1. Illustrate controllability in discrete-time systems.
2. Explain pole placement in state-space design, .
3. Compare between a reduced-order and a full-order observer .

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EE4P41

Course Name: : DIGITAL CONTROL SYSTEM

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain ZOH method for sampling and reconstruction in discrete control systems .
2. Discuss the role of the pulse transfer function in the design of digital control systems .
3. Examine magnitude and phase angle condition of a system for root locus.
4. Describe Routh-Hurwitz method in w-plane .
5. List the advantages of using the root locus method for compensator design in digital control systems.
6. Explain the steps involved in the direct design of a digital controller using frequency response.
7. Analyse the state-space approach in discrete control system design.
8. A discrete time system is described by the difference equation
$$y(k+2) + 3y(k+1) + 5y(k) = u(k)$$
Determine the transfer function of the system .
9. Illustrate observability in discrete-time systems.
10. Compare between a reduced-order and a full-order observer .

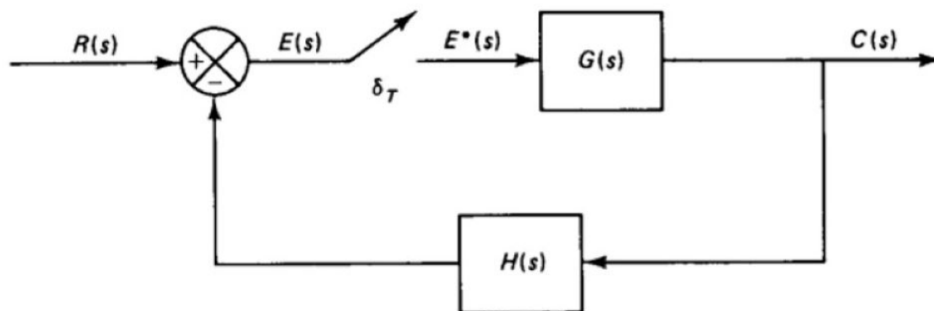
PART B

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

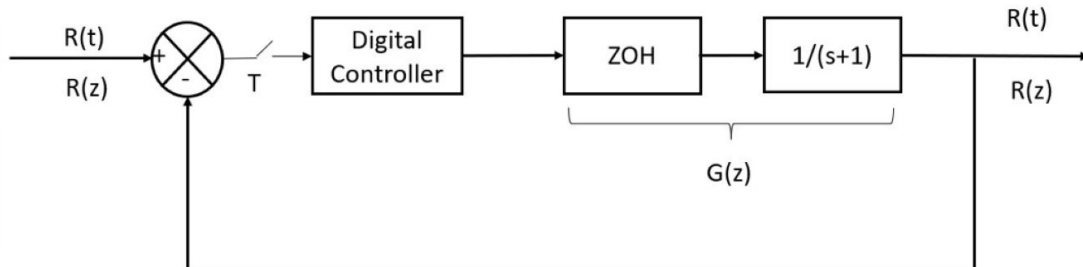
11. Describe how the mapping from the s-plane to the z-plane affects the system's constant damping loci and constant frequency loci. (14 marks)

OR

12. Derive the pulse transfer function of a closed-loop system as shown below. (14 marks)



13. Draw root locus diagram in the z plane for the system shown below. Assume $T=0.5$ sec and integral controller is used. (14 marks)



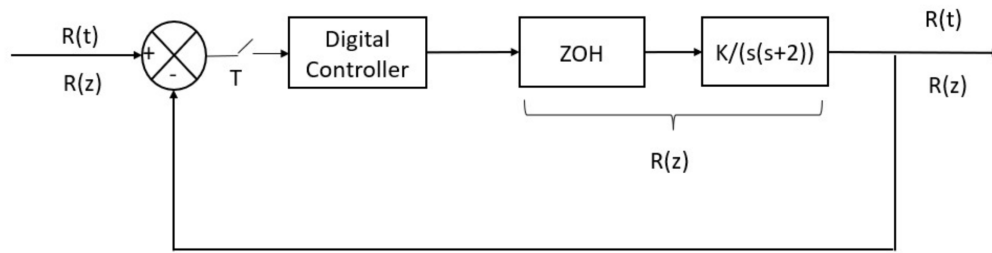
OR

14. Suppose the characteristic equation of a system is given by
$$P(z) = 2z^4 - 1.2z^3 + 0.07z^2 + 0.3z - 0.08$$

Check stability using Jury's Stability theorem. (14 marks)
15. Identify the steps involved in the design of a lead compensator based on the frequency response method. (14 marks)

OR

16. For the system shown, design a digital controller to meet the following specifications:
Velocity error constant $K_v = 6$; Peak overshoot to step input $\leq 15\%$; Settling time < 5 sec ; Assume $T = 0.2$ sec. (14 marks)



17. Illustrate the state transition matrix and explain computations with an example. List properties of the state transition matrix. (14 marks)

OR

18. Consider the system $x(k+1) = Ax(k) + Bu(k)$, $y(k) = Cx(k)$ where

$$A = \begin{bmatrix} -3 & 0 \\ 0 & -2 \end{bmatrix}; B = \begin{bmatrix} 1 \\ 1 \end{bmatrix}; C = \begin{bmatrix} -1 & 1 \end{bmatrix}$$

Find the state transition matrix.

(14 marks)

19. Consider the system $x(k+1) = Ax(k) + Bu(k)$, $y(k) = Cx(k)$ where

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & 11 & -6 \end{bmatrix}; B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}; C = \begin{bmatrix} 4 & 5 & 1 \end{bmatrix}$$

Analyse the controllability and observability of the system.

(14 marks)

OR

20. Determine the state feedback gain matrix K for the following system (14 marks)

$$x(k+1) = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix} * x(k) + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} * u(k)$$

such that the closed loop poles are located at 0.5, 0.6 and 0.7.

B24EE4P42	ENERGY STORAGE SYSTEMS FOR EV	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The course aims to provide a comprehensive understanding of energy storage systems and their application in electric and hybrid electric vehicles. It covers various energy storage technologies, fuel cells, batteries, and electric vehicle charging systems including vehicle–grid interaction and charging infrastructure. Upon completion, students will be able to evaluate energy storage, charging technologies, and the integration of electric vehicles with modern power grids.

Prerequisites

Nil

Course Outcomes

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

CO 1	Illustrate the different types of energy storage systems and their performance. (Cognitive Knowledge Level: Understand)
CO 2	Understand types of fuel cells, operation, hydrogen storage methods, and ultra-capacitor technologies for electric vehicles. (Cognitive Knowledge Level: Understand)
CO 3	Understand different battery technologies, their parameters, and energy storage characteristics for electric vehicles. (Cognitive Knowledge Level: Understand)
CO 4	Analyze the architecture, operation of electric vehicle battery charging standards and connector configuration. (Cognitive Knowledge Level: Apply)
CO 5	Analyse electric vehicle charging systems and vehicle–grid interfaces. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	30	20	20
Understand	70	40	40
Apply		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 (7 hours)

Introduction to EV and Energy Storage Systems

Introduction to electric vehicles and hybrid vehicles - social and economic importance of electric vehicles - types of EVs - battery electric vehicles, plug-in hybrid electric vehicles, fuel cell electric vehicles, hybrid electric vehicles, types of HEVs - series hybrid, parallel hybrid, series - parallel hybrid, electric and hybrid vehicle components - Different types of energy storage - mechanical energy storage - flywheel storage, compressed air energy storage, electrochemical energy storage - secondary batteries, fuel cell, super conducting magnetic energy storage.

MODULE 2 (8 hours)

Fuel Cells, Hydrogen Storage and Ultracapacitor

Principle of operation of fuel cell, fuel cell characteristics, types of fuel cells - liquid and methanol types, alkaline fuel cell (AFC), proton exchange membrane fuel cell, direct methanol fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, comparison, fuel cell model, fuel cell electric vehicle - case study.

Hydrogen Storage - compressed hydrogen, cryogenic liquid hydrogen, metal hydrides. Ultracapacitors - features of ultracapacitors, basic principles of ultracapacitors, performance of ultracapacitors, ultracapacitor technologies.

MODULE 3 (7 hours)

Battery Energy Storage

Electrochemical batteries, electrochemical reactions, thermodynamic voltage, battery parameters - C-rating, SoC, DoD, specific energy, specific power, energy efficiency. Battery technologies - Lead-Acid batteries, Nickel-based batteries - Nickel/Iron system, Nickel/Cadmium system, Nickel-Metal hydride battery, Lithium-based batteries - Lithium-Polymer (Li-P) battery, Lithium-Ion (Li-Ion) battery.

MODULE 4 (8 hours)

Overview of Electric Vehicle Battery Chargers

On-board chargers, Electric Vehicle Supply Equipment (EVSE) - Grid to EVSE to on-board chargers to battery pack, power flow block schematic diagrams, types of charging stations - AC Level 1 and 2, DC - Level 3, vehicle-to-grid (V2G) concept, overview of charging standards - SAE J1772, VDE-AR-E 2623-2-2, JEVs G105-1993, IEC 61851- electric vehicle conductive charging modes, IEC 61980 - electric vehicle wireless power transfer systems, IEC 62196 - AC couplers configuration, combo AC DC couplers and IS- 17017 standards

for EV charging, types of connectors - CHAdeMo, CCS Type1 and 2, GB/T - pin diagrams and difference.

MODULE 5 (6 hours)

Electric Vehicles and Power Grid

Vehicle grid interface - G2V, V2G, V2V and V2H frameworks, electric vehicle charging - DC fast chargers - 480 V fast charger, MV fast charger, electric vehicle charging station, grid impacts on fast chargers, electric vehicles in micro grid - microgrids and control, V2H and H2V power converter, solar generation - integration with electric vehicles.

Text Books

1. A.G. Ter-Gazarian, *Energy Storage for Power Systems*, The Institution of Engineering and Technology (IET) Publication, 3rd ed., 2020.
2. Iqbal Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, Pearson Education India, 3rd ed., 2021.
3. Mehrdad Ehsani, Yimin Gao and Ali Emadi, *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles*, CRC Press, 2nd ed., 2010.
4. Dr. Dileep G, *Distributed generation and smart grid*, Advay publications, 1st ed., 2018.

Reference Books

1. Chris Mi, M A Masrur and D W Gao, *Hybrid Electric Vehicles – Principles and applications with practical perspectives*, Wiley, 1st ed., 2011.
2. *Hand book of electric vehicle charging and infrastructure implementation*, Government of India, Ministry of power.
3. *The Evolution of EV Charging Standards: From SAE J1772 to ISO 15118*
4. Francisco Diaz-Gonzalez, Andreas Sumper, Oriol Gomis-Bellmunt, *Energy Storage in Power Systems Wiley Publication*, ISBN:978-1-118-97130-7, 2016.
5. James Larminie and John Lowry, *Electric Vehicle Technology Explained*, Wiley, 1st ed., 2018.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to EV and Energy Storage Systems	7
1.1	Introduction to electric vehicles and hybrid vehicles, social and economic importance of electric vehicles	1
1.2	Electric vehicles, types of EVs, battery electric vehicles,	1
1.3	Plug-in hybrid electric vehicles, fuel cell electric vehicles	1
1.4	Hybrid electric vehicles, types of HEVs, series hybrid, parallel hybrid, series-parallel hybrid	1
1.5	Different types of energy storage, mechanical energy storage, flywheel storage, compressed air energy storage	1
1.6	Electrochemical energy storage - secondary batteries, fuel cell-schematic diagram of an electrochemical fuel cell, thermal regime, power extraction system	1
1.7	Super conducting magnetic energy storage-Basic principles, superconducting coils, cryogenic systems, power extraction	1
	Module 2: Fuel Cells, Hydrogen Storage and Ultra capacitor	8
2.1	Principle of operation of fuel cell, fuel cell characteristics	2
2.2	Types of fuel cells - liquid and methanol types, alkaline fuel cell (AFC), proton exchange membrane fuel cell, direct methanol fuel cell	2
2.3	Phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, comparison, fuel cell model, fuel cell electric vehicle - case study.	2
2.4	Hydrogen Storage - compressed hydrogen, cryogenic liquid hydrogen, metal hydrides	1
2.5	Ultracapacitors - features of ultracapacitors, basic principles of ultracapacitors, performance of ultracapacitors, ultracapacitor technologies	1
	Module 3: Battery Energy Storage	7
3.1	Electrochemical batteries, electrochemical reactions, thermodynamic voltage	1
3.2	Battery parameters - C-rating, SoC, DoD, specific energy, specific power, energy efficiency	1
3.3	Battery technologies - Lead-Acid batteries	1
3.4	Nickel-based batteries - Nickel/Iron system, Nickel/Cadmium system, Nickel-Metal hydride battery	2
3.4	Lithium-based batteries - Lithium-Polymer (Li-P) battery, Lithium-Ion (Li-Ion) battery	2

	Module 4: Overview of Electric Vehicle Battery Chargers	8
4.1	On-board chargers, Electric Vehicle Supply Equipment (EVSE) - Grid to EVSE to on-board chargers to battery pack	2
4.2	Power flow block schematic diagrams, types of charging stations - AC Level 1 and 2, DC - Level 3, vehicle-to-grid (V2G) concept	2
4.3	Overview of charging standards - SAE J1772, VDE-AR-E 2623-2-2, JEVS G105-1993, IEC 61851- electric vehicle conductive charging modes	2
4.4	IEC 61980 - electric vehicle wireless power transfer systems, IEC 62196 - AC couplers configuration, combo AC DC couplers and IS- 17017 standards for EV charging	1
4.5	Types of connectors - CHAdeMo, CCS Type1 and 2, GB/T - pin diagrams and difference	1
	Module 5: Electric Vehicles and Power Grid	6
5.1	Vehicle grid interface - G2V, V2G, V2V and V2H frameworks	1
5.2	Electric vehicle charging - DC fast chargers - 480 V fast charger, MV fast charger	2
5.3	Electric vehicle charging station, grid impacts on fast chargers	1
5.4	Electric vehicles in micro grid - microgrids and control, V2H and H2V power converter	1
5.5	Solar generation - integration with electric vehicles	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the components of EVs and HEVs.
2. Describe the working principle of Flywheel energy storage system.
3. Describe the basic principle and working of superconducting magnetic energy storage system.

Course Outcome 2 (CO 2)

1. Explain the working of fuel cell.
2. Discuss the types of fuel cell.

3. Describe battery parameters.
4. Discuss the construction and working of a Nickel–Cadmium battery

Course Outcome 3 (CO 3)

1. Describe battery parameters.
2. Explain the working of Li-ion batteries.
3. Explain the working of Lead acid battery.

Course Outcome 4 (CO 4)

1. Explain the different charging systems used for charging of EV.
2. Describe different types of connectors.
3. Discuss the function of an on-board charger in an electric vehicle.

Course Outcome 5 (CO 5)

1. Explain Grid to Vehicle (G2V) concept.
2. Describe the working of DC fast chargers.
3. Describe the concept of microgrids and their relevance to EV integration.
4. Explain the structure and components of an electric vehicle charging station.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EE4P42

Course Name: : ENERGY STORAGE SYSTEMS FOR EV

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Describe the main components of electric and hybrid vehicles.
2. Explain the social and economical impacts of electric vehicles.
3. Explain the basic principle of energy storage in ultracapacitors.
4. Discuss the working of fuel cell along with schematic diagram.
5. What is meant by the C rating of a battery? Explain with an example.
6. Explain the working of Li-ion batteries.
7. Describe the power flow path from the grid to the EV battery pack.
8. Define the function of an on-board charger in an electric vehicle.
9. Describe the concept of microgrids and their relevance to EV integration.
10. Explain the working principle of DC fast chargers used in electric vehicles.

PART B

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

11. (a) Describe the working of superconducting magnetic energy storage system. (7 marks)
- (b) Explain the concept of series and parallel configurations of EV. (7 marks)

OR

12. (a) What is the basic principle behind CAES? With a neat labelled diagram explain the working of a compressed air energy storage system. (8 marks)
- (b) Explain different types of electric vehicles. (6 marks)
13. (a) Discuss the performance characteristics of ultracapacitors and their advantages over conventional capacitors and batteries. (8 marks)
- (b) Differentiate between compressed hydrogen storage and cryogenic liquid hydrogen storage. (6 marks)

OR

14. Describe different types of fuel cells and explain their working principles. (14 marks)
15. (a) Discuss the construction and working of a Nickel–Cadmium battery. (7 marks)
- (b) Explain the working of Lead acid batteries using proper chemical equations. What are its disadvantages? (7 marks)

OR

16. (a) Describe the following battery parameters i) SoC , ii) DoD, iii) specific energy, iv) specific power. (8 marks)
- (b) Discuss the thermodynamic voltage of an electrochemical cell. (6 marks)
17. (a) With pin diagrams, describe the CCS Type 2 connectors used for EV charging. (6 marks)
- (b) Explain the difference between AC Level 1 and AC Level 2 charging in terms of voltage, current, and charging time. (8 marks)

OR

18. (a) Draw and explain the block schematic diagram of EV charging power flow. (7 marks)
- (b) Describe the features and advantages of CHAdeMO connectors used in EV charging. (7 marks)
19. (a) Describe the 480 V fast charger and its applications in EV charging infrastructure. (6 marks)
- (b) Explain the concept of solar generation integrated with electric vehicle charging. (8 marks)

OR

20. Compare the G2V, V2G, V2V, and V2H frameworks used in electric vehicle energy management systems. (14 marks)

B24EE4P43	COMPUTER AIDED POWER SYSTEM ANALYSIS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4		

Preamble

The aim of this course is to introduce students to computer-aided methods for modelling and analysing power system networks. The course covers network formulation using graph theory, solution of large system equations, load flow analysis, optimal operation, and fault calculations. After completing the course, students will be able to apply numerical techniques to analyse power system performance and support planning, operation, and security studies.

Prerequisites

Power Systems II

Course Outcomes

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

CO 1	Apply graph theory to formulate network matrices and model power system networks (Cognitive Knowledge Level: Apply)
CO 2	Apply matrix factorization and elimination techniques to efficiently solve large power system linear equations (Cognitive Knowledge Level: Apply)
CO 3	Formulate and solve power system load flow problems using DC and AC–DC load flow models (Cognitive Knowledge Level: Apply)
CO 4	Optimize power system operation by scheduling generation and unit commitment under economic and security constraints (Cognitive Knowledge Level: Apply)
CO 5	Determine post-fault system conditions and contingency effects using network matrix methods (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
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				1		1
CO 4	3	2	2	2	1				1		1
CO 5	3	2	2	2	1				1		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/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 (7 hours)

Graph Theory for Power System Analysis

Introduction to graph theory, definitions - graph, rank, sub-graph, path, planar graph, closed path, oriented graph, tree, co-tree, loops, cut-set. Incidence matrix (IM) - element-node IM, bus IM, branch-path IM, cut-set IM, loop IM. Network performance equations, network matrices - Zbus, Ybus, development of network matrices by singular transformation, bus admittance matrix formulation by direct inspection, cases of modification of an existing Zbus (elements without mutual coupling), numerical problems.

Use any power system simulation software for the formation of admittance matrix and study the network modification effects (Assignment/Tutorial only).

MODULE 2 (8 hours)

Solution of Linear System of Equations

Techniques for solving linear system of equations - Gauss-Jordan method, Gauss elimination, LDU factorisation. Inversion of Ybus for large systems - using LDU factors, Tinney's optimally ordered triangular factorisation, numerical problems.

MODULE 3 (7 hours)

Load Flow Analysis

Review of Load Flow analysis - DC load flow - formulation of load flow problem, DC load flow solution (two iterations). AC-DC load flow (qualitative analysis) - problem formulation, DC system model, sequential algorithm for single-phase AC-DC load flow, extension to multi-terminal DC system, DC convergence tolerance.

Use any power system simulation software for solving the DC load flow problem (Assignment/Tutorial only).

MODULE 4 (7 hours)

Optimal System Operation

Adjustment of network operating conditions, optimal operation of generators on a bus bar - generator operating cost, optimal operation, numerical problems. Optimal unit commitment - dynamic programming method, reliability considerations - Patton's security function, security constrained optimal unit commitment, start-up considerations. Optimum generation scheduling, optimal load flow solution (qualitative analysis).

MODULE 5 (7 hours)

Network Fault and Contingency Calculations

Network fault calculation using - Zbus, Ybus Table of Factors, algorithm for calculating system conditions after fault - three-phase to ground fault. Contingency analysis - contingencies using Zbus in a Superposition Method, Zbus line method, Ybus Table of Factors, numerical problems.

Text Books

1. George L. Kusic, *Computer-Aided Power Systems Analysis*, CRC Press, 2nd ed., 2018.
2. D. P. Kothari, I. J. Nagrath, and R. K. Saket, *Modern Power System Analysis*, McGraw Hill, 5th ed., 2022.
3. P. S. R. Murty, *Power System Analysis*, BS Publications, 3rd ed., 2023.
4. J. Arrillaga and C. P. Arnold, *Computer Analysis of Power Systems*, John Wiley & Sons, 1st ed., 1990.

Reference Books

1. M. A. Pai and Dheeman Chatterjee, *Computer Techniques in Power System Analysis*, McGraw Hill Education, 3rd ed., 2014.
2. John J. Grainger and William D. Stevenson, *Power System Analysis*, McGraw-Hill Education, 2nd ed., 2016.
3. Hadi Saadat, *Power System Analysis*, PSA Publishing, 3rd ed., 2011.
4. Glenn W. Stagg and Ahmed H. El-Abiad, *Computer Methods in Power System Analysis*, Medtech Science Press, 2nd ed., 2019.
5. Ramasamy Natarajan, *Computer-Aided Power System Analysis*, CRC Press, 1st ed., 2024.
6. Reijer Idema and Domenico J. P. Lahaye, *Computational Methods in Power System Analysis*, Atlantis Press, 1st ed., 2014.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Graph Theory for Power System Analysis	7

1.1	Introduction to graph theory, definitions - graph, rank, sub-graph, path, planar graph, closed path, oriented graph, tree, co-tree, loops, cut-set	1
1.2	Incidence matrix (IM) - element-node IM, bus IM, branch-path IM, cut-set IM, loop IM	1
1.3	Network performance equations, network matrices - Zbus, Ybus	1
1.4	Development of network matrices by singular transformation	1
1.5	Bus admittance matrix formulation by direct inspection	1
1.6	Cases of modification of an existing Zbus (elements without mutual coupling), numerical problems	2
	Module 2: Solution of Linear System of Equations	8
2.1	Techniques for solving linear system of equations - Gauss-Jordan method	1
2.2	Gauss elimination method	1
2.3	LDU factorisation, numerical problems	2
2.4	Inversion of Ybus for large systems - using LDU factors, numerical problems	2
2.5	Tinney's optimally ordered triangular factorisation, numerical problems	2
	Module 3: Load Flow Analysis	7
3.1	Review of Load Flow analysis - DC load flow - formulation of load flow problem	1
3.2	DC load flow solution (two iterations)	1
3.3	AC-DC load flow (qualitative analysis) - problem formulation	1
3.4	DC system model	1
3.5	Sequential algorithm for single-phase AC-DC load flow	1
3.6	Extension to multi-terminal DC system, DC convergence tolerance	2
	Module 4: Optimal System Operation	7
4.1	Adjustment of network operating conditions	1
4.2	Optimal operation of generators on a bus bar - generator operating cost, optimal operation, numerical problems	2
4.3	Optimal unit commitment - dynamic programming method	1
4.4	Reliability considerations - Patton's security function	1
4.5	Security constrained optimal unit commitment, start-up considerations	1
4.6	Optimum generation scheduling, optimal load flow solution (qualitative analysis)	1
	Module 5: Network Fault and Contingency Calculations	7
5.1	Network fault calculation using - Zbus, Ybus Table of Factors	2
5.2	Algorithm for calculating system conditions after fault - three-phase to ground fault	1

5.3	Contingency analysis - contingencies using Zbus in a Superposition Method	1
5.4	Zbus line method	1
5.5	Ybus Table of Factors, numerical problems	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the basic cutset incidence matrix with an example.
2. Problems on Ybus formulation.
3. Problems on Zbus modifications.

Course Outcome 2 (CO 2)

1. Explain Tinny's optimal ordering schemes.
2. Problems on LDU factorisation.
3. Problems on Gauss elimination method.

Course Outcome 3 (CO 3)

1. Explain the DC load flow analysis with necessary assumptions.
2. Describe the need for power flow analysis.
3. Problems on DC load flow analysis.

Course Outcome 4 (CO 4)

1. Explain the need of optimum generation scheduling.
2. Problems on generator operating costs.
3. Problems on optimal operation of power system.

Course Outcome 5 (CO 5)

1. Describe the need for contingency analysis in power systems.
2. Problems on network fault analysis.
3. Problems on contingency analysis.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EE4P43

Course Name: : COMPUTER AIDED POWER SYSTEM ANALYSIS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define the following terms with suitable example: tree, branch, co-tree, and link.
2. Explain bus incidence matrix with an example.
3. What are LDU factors of a matrix?
4. Explain Tinney's schemes of near optimal ordering.
5. Illustrate the importance of load flow studies.
6. Describe the principle applied in the decoupled approach of load flow solutions.
7. Define optimal unit commitment in power system operation.
8. Explain the constraints considered in formulating optimal power flow.
9. Explain the importance of short circuit studies in power system analysis.
10. State the causes of contingencies in power systems.

PART B

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

11. Derive the expression for bus admittance matrix Y_{BUS} in terms of primitive admittance matrix $[y]$ and bus incidence matrix A .

OR

12. With an example, obtain the branch admittance matrix, using basic cutset incidence matrix.
13. Explain the algorithm of Gauss Jordan Elimination method.

OR

14. Determine the LDU factorization of the matrix $A = \begin{bmatrix} 1 & 2 & 2 \\ 4 & 4 & 2 \\ 4 & 6 & 4 \end{bmatrix}$
15. Discuss in detail the steps involved in the AC-DC load flow analysis.

OR

16. Explain the process of DC load flow analysis.
17. Describe the security constrained optimal unit commitment with necessary equations.

OR

18. Formulate and explain the optimal power flow problem with equality constraints.
19. Derive the necessary mathematical relations for computing the system conditions of a power system network after the occurrence of a three-phase to ground fault through a fault impedance (Z_f) per phase.

OR

20. Explain contingency analysis using Z_{BUS} in a superposition method.

B24EE4P44	DIGITAL IC DESIGN	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course aims to equip students with the principles and techniques used to design integrated circuits that implement digital logic systems. It covers the analysis and design of CMOS devices, combinational and sequential logic circuits, and interconnects with emphasis on performance, power, and reliability.

Prerequisites

Electronics Circuits II

Course Outcomes

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

CO 1	Describe different quality metrics and issues of digital design and understand static and dynamic behavior of CMOS inverters. (Cognitive Knowledge Level: Understand)
CO 2	Design arithmetic building blocks including adders and multipliers. (Cognitive Knowledge Level: Apply)
CO 3	Design memory and array structures. (Cognitive Knowledge Level: Apply)
CO 4	Describe timing metrics for sequential circuits and analyse static latches and registers. (Cognitive Knowledge Level: Apply)
CO 5	Design dynamic latches and registers including non bistable sequential circuits. (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	2	1		1	1	1		1
CO 2	3	2	1	2	1		1	1	1		1
CO 3	3	2	1	2	1		1	1	1		1
CO 4	3	1	1	2	1		1	1	1		1
CO 5	3	1	1	2	1		1	1	1		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/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 (8 hours)

Introduction to Digital IC design

Issues in digital integrated circuit design, quality metrics of a digital design - cost of an integrated circuit, functionality and robustness, performance, power and energy consumption.

CMOS Inverter

Introduction, static CMOS inverter, evaluating robustness of CMOS inverter - static behavior, switching threshold, noise margins, device variations and scaling supply voltage, power, energy, and energy delay - dynamic power consumption, dynamic dissipation due to charging and discharging capacitances, dissipation due to direct path currents, static consumption.

MODULE 2 (7 hours)

Designing Arithmetic Building Blocks

Introduction, data paths in digital processor architecture, adder - binary adder definitions, full adder circuit design considerations - static adder circuit, mirror adder design, transmission gate based adder, Manchester carry chain adder, binary adder logic design considerations - carry bypass adder, linear carry select adder, multiplier - definitions, partial product generation, partial product accumulation – array multiplier, carry save multiplier, tree multiplier, final addition, shifter - barrel shifter, logarithmic shifter.

MODULE 3 (7 hours)

Designing Memory and Array Structures

Introduction - memory classification, memory architecture and building blocks, memory core - read only memories (ROM), programming ROM memory - floating gate transistor, EPROM, EEPROM, flash EEPROM, nonvolatile read-write memories, read-write memories (RAM), addressable or associative memory (CAM), memory peripheral circuitry - address decoders, sense amplifiers, voltage references, drivers/buffers, timing and control.

MODULE 4 (7 hours)

Designing Sequential Logic Circuits

Introduction, timing metrics for sequential circuits, classification of memory elements - foreground versus background memory, static versus dynamic memory, latches versus registers.

Static Latches and Registers

The bistability principle, multiplexer-based latches, master-slave edge triggered register - timing properties of multiplexer-based master slave registers, non-ideal clock signals, low voltage static latches, static SR flip-flop.

MODULE 5 (7 hours)

Dynamic Latches and Registers

Dynamic transmission-gate edge triggered registers, C^2 MOS register, dual edge registers, True Single-Phase Clocked Register (TSPCR), pipelining - latch vs. register based pipelines, NORA (NOt RAcE) CMOS - A Logic Style for Pipelined structures, non-bistable sequential circuits - schmitt trigger - CMOS implementation, monostable sequential circuits, astable circuits.

Text Books

1. Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic, *Digital Integrated Circuits – A design perspective*, PHI India, 2nd ed., 2003.
2. Ken Martin, *Digital Integrated Circuit Design*, Oxford University Press, 2011.
3. Sung-Mo Kang, Yusuf Leblebici, *CMOS Digital Integrated Circuits*, McGraw Hill Education Private Limited, 3rd ed.,.

Reference Books

1. Sedra and Smith, *Microelectronic Circuits*, Oxford Publications, 5th ed., 2005.
2. Jackson and Hodges, *Analysis and Design of Digital Integrated circuits*, TMH Publication, 3rd ed., 2005.
3. Victor P Nelson, Bill D Carrol *Digital Logic Circuit, Design and Analysis* ,Pearson Publication , 2nd ed..

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Digital IC design	8
1.1	Issues in digital integrated circuit design	1

1.2	Quality metrics of a digital design - cost of an integrated circuit, functionality and robustness, performance, power and energy consumption.	1
	CMOS Inverter	
1.3	Introduction, static CMOS inverter	1
1.4	Evaluating robustness of CMOS inverter - static behavior, switching threshold	1
1.5	Noise margins, device variations and scaling supply voltage	1
1.6	Power, energy, and energy delay - dynamic power consumption	1
1.7	Dynamic dissipation due to charging and discharging capacitances	1
1.8	Dissipation due to direct path currents, static consumption	1
	Module 2: Designing Arithmetic Building Blocks	7
2.1	Introduction, data paths in digital processor architecture, adder – binary adder definitions	1
2.2	Full adder circuit design considerations – static adder circuit, mirror adder design, transmission gate based adder	1
2.3	Manchester carry chain adder	1
2.4	Binary adder logic design considerations – carry bypass adder, linear carry select adder	1
2.5	Partial product accumulation – array multiplier, carry save multiplier, tree multiplier	1
2.6	Multiplier -definitions, partial product generation	1
2.7	Final addition, shifter – barrel shifter, logarithmic shifter.	1
	Module 3: Designing Memory and Array Structures	7
3.1	Introduction - memory classification	1
3.2	Memory architecture and building blocks	1
3.3	Memory core – read only memories (ROM)	1
3.4	Programming ROM memory – floating gate transistor	1
3.5	EPROM, EEPROM, flash EEPROM	1
3.6	Nonvolatile read-write memories, read-write memories(RAM), addressable or associative memory(CAM)	1
3.7	Memory peripheral circuitry – address decoders, sense amplifiers, voltage references, drivers/buffers, timing and control	1
	Module 4: Designing Sequential Logic Circuits	7
4.1	Introduction, timing metrics for sequential circuits	1
4.2	Classification of memory elements – foreground versus background memory	1
4.3	Static versus dynamic memory, latches versus registers	1
4.4	The bistability principle, multiplexer-based latches	1
4.5	Master-slave edge triggered register – timing properties of multiplexer-based master slave registers	1
4.6	Non-ideal clock signals, low voltage static latches	1
4.7	Static SR flip-flop	1

	Module 5: Dynamic Latches and Registers	7
5.1	Dynamic Transmission-Gate Edge triggered Registers	1
5.2	C^2MOS register, dual edge registers	1
5.3	True Single-Phase Clocked Register (TSPCR)	1
5.4	Pipelining - Latch vs. Register Based Pipelines	1
5.5	NORA (NOt RAce) CMOS—A Logic Style for Pipelined structures	1
5.6	Non-Bistable sequential circuits - Schmitt trigger- CMOS implementation	1
5.7	Monostable sequential circuits, astable circuits	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Enlist different issues in digital IC design.
2. Describe switching threshold in CMOS inverter.
3. Explain how robustness of CMOS inverter can be evaluated.

Course Outcome 2 (CO 2)

1. What are the design considerations of a full adder?
2. Describe Manchester carry chain adder.
3. Illustrate partial product generation of multiplier.

Course Outcome 3 (CO 3)

1. Describe memory classification of digital circuits.
2. Discuss different types of ROM memory.
3. What is meant non volatile read - write memory?

Course Outcome 4 (CO 4)

1. Compare and contrast static memory and dynamic memory.
2. Explain the bistability principle of static latches and registers.

3. Illustrate the properties of master-slave edge triggered register.

Course Outcome 5 (CO 5)

1. Explain C^2MOS .
2. Describe the operation and design of schmitt trigger.
3. Discuss monostable and astable sequential circuits.



MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EE4P44

Course Name: : DIGITAL IC DESIGN

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. List any three issues in digital integrated circuit design.
2. Define the term quality metrics in digital IC design.
3. What is a mirror adder?
4. State the principle of a transmission gate based adder.
5. Illustrate Read-Write Memory (RAM)?
6. Describe the function of an address decoder?
7. Define a multiplexer-based latch.
8. What is a master-slave edge triggered register?
9. Discuss dual edge triggered register?
10. Write short note on metastability.

PART B

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

11. (a) Compare static and dynamic power consumption in CMOS inverters with suitable examples. (7 marks)
(b) Explain the switching threshold and noise margins of CMOS inverter. (7 marks)

OR

12. (a) Evaluate the robustness of a CMOS inverter considering static behavior, switching threshold, and noise margins. (7 marks)
(b) With a neat diagram, explain the static CMOS inverter and its operation. (7 marks)
13. (a) Discuss the design considerations of a full adder circuit. (8 marks)
(b) Explain the working of Manchester carry chain adder with a neat diagram. (6 marks)

OR

14. With diagrams, discuss array multiplier, carry save multiplier, and tree multiplier.
15. (a) Explain the classification of memories with suitable examples. (7 marks)
(b) Discuss the operation and structure of ROM. (7 marks)

OR

16. (a) Compare different types of programmable ROM technologies. (8 marks)
(b) Discuss the structure and working of Flash EEPROM. (6 marks)
17. (a) Describe the bistability principle with suitable explanation. (8 marks)
(b) Explain the design and operation of low voltage static latches. (6 marks)

OR

18. (a) Explain the difference between static and dynamic memory elements. (8 marks)
(b) Explain the operation of multiplexer-based latches with diagram. (6 marks)
19. (a) Describe the C²MOS register and its working principle. (8 marks)
(b) Discuss the True Single Phase Clocked Register (TSPCR). (6 marks)

OR

20. (a) Describe the NORA CMOS logic style and its application in pipelined structures. (8 marks)
(b) Explain the CMOS implementation of a Schmitt trigger. (6 marks)

B24EE4P45	DIGITAL SIGNAL PROCESSING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course provides a systematic foundation in digital signal processing by emphasizing discrete-time signal analysis and implementation concepts. It encompasses discrete Fourier analysis, digital filter design, efficient computational algorithms, realization structures, multirate signal processing techniques, and an overview of DSP processor architecture. The course equips students with the ability to analyze, design, and implement digital signal processing systems suitable for real-time engineering applications.

Prerequisites

Signals and systems

Course Outcomes

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

CO 1	Analyze discrete-time systems using the discrete Fourier transform and fast Fourier transform for frequency-domain interpretation. (Cognitive Knowledge Level: Apply)
CO 2	Design and realize infinite impulse response filters. (Cognitive Knowledge Level: Apply)
CO 3	Design and realize finite impulse response filters. (Cognitive Knowledge Level: Apply)
CO 4	Evaluate the effects of finite word length in digital filters and understand multirate digital signal processing concepts. (Cognitive Knowledge Level: Understand)
CO 5	Apply multirate digital signal processing concepts and analyze discrete-time systems using fast Fourier transform and architectural understanding of DSP processors. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	2	1	1						1
CO 2	3	2	2	1	1						1
CO 3	3	2	2	1	1						1
CO 4	3	2	2	1							1
CO 5	3	2	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	20	40	20
Apply	60	40	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 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)

Discrete Fourier Transform

Introduction to the DSP system. Discrete Fourier Transform (DFT) - time domain aliasing due to frequency sampling, inverse DFT (IDFT), relation of DFT to Z-transform and DTFT, properties of DFT, frequency response analysis of signals using the DFT, circular convolution using DFT, linear convolution from circular convolution, linear filtering based on DFT.

Fast Fourier Transform (FFT) - radix-2 decimation in time FFT algorithm, radix-2 decimation in frequency algorithm, IDFT using FFT algorithm.

MODULE 2 (7 hours)

Infinite Impulse Response (IIR) Filters

Frequency selective filters, discrete-time IIR filter from analog filter (Butterworth), IIR filter design - impulse invariance, bilinear transformation, frequency transformations in the analog domain.

Realization of IIR Systems: direct-form I, direct-form II, cascade-form, parallel-form, and lattice structures.

MODULE 3 (7 hours)

Finite Impulse Response (FIR) Filters

Linear phase FIR filter, filter design using windowing techniques - Rectangular, Hanning, Hamming. Frequency sampling techniques of designing FIR filters. Structures for FIR systems - direct-form structure, cascade-form structures, linear phase realization, lattice structure.

MODULE 4 (6 hours)

Finite Word Length Effects in Digital Filters

Fixed-point and floating-point number representations, comparison, truncation and rounding errors, quantization noise, derivation for quantization noise power, coefficient quantization error, product quantization error, overflow error, round-off noise power, limit cycle oscillations due to product quantization and overflow errors, signal scaling.

MODULE 5 (7 hours)

Multi-rate Digital Signal Processing

Decimation and interpolation - time domain and frequency domain interpretation, anti-imaging filter.

Introduction to DSP Processors

Harvard architecture, Multiply Accumulate Unit (MAC), pipelining, architecture of TMS320C50 digital signal processor, addressing modes, simple programs - arithmetic operations, wave-form generations.

Text Books

1. John G. Proakis and Dimitris G. Manolakis, *Digital Signal Processing: Principles, Algorithm & Application*, Pearson, 5th ed., 2021.
2. P. Ramesh Babu, *Digital Signal Processing*, Scitech Publications (India) Pvt Ltd, 7th ed., 2014.
3. A. Anand Kumar, *Digital Signal Processing*, 3rd ed., PHI Learning, 2019.

Reference Books

1. Emmanuel C. Ifeachor and Barrie W. Jervis, *Digital Signal Processing – A Practical Approach*, Pearson Education, 2nd ed., 2009.
2. S. Salivahanan, A. Vallavaraj, and C. Gnapriya, *Digital Signal Processing*, Tata McGraw Hill, 4th ed., 2019.
3. A. Oppenheim and R. Schaffer, *Discrete-Time Signal Processing*, Pearson Education, 3rd ed., 2014.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Discrete Fourier Transform	9
1.1	Introduction to the DSP system. Discrete Fourier Transform	1
1.2	Time domain aliasing due to frequency sampling, inverse DFT, relation of DFT to Z-transform and DTFT	1

1.3	Properties of DFT (proof not required), frequency response analysis of signals using the DFT	2
1.4	Circular convolution using DFT, linear convolution from circular convolution	1
1.5	Linear filtering based on DFT	1
1.6	Fast Fourier Transform - radix-2 decimation in time FFT algorithm	1
1.7	Radix-2 decimation in frequency algorithm, IDFT using FFT algorithm	2
	Module 2: Infinite Impulse Response (IIR) Filters	7
2.1	Frequency selective filters, discrete-time IIR filter from analog filter (Butterworth)	2
2.2	IIR filter design - impulse invariance	1
2.3	Bilinear transformation	1
2.4	Frequency transformations in the analog domain	1
2.5	Realization of IIR Systems: direct-form I, direct-form II	1
2.6	Cascade-form, parallel-form, and lattice structures.	1
	Module 3: Finite Impulse Response (FIR) Filters	7
3.1	Linear phase FIR filter, filter design using windowing techniques - Rectangular window	2
3.2	Filter design using Hanning window	1
3.3	Filter design using Hamming window	1
3.4	Frequency sampling techniques of designing FIR filters	1
3.5	Structures for FIR systems - direct-form structure, cascade-form structures	1
3.6	Linear phase realization, lattice structure	1
	Module 4: Finite Word Length Effects in Digital Filters	6
4.1	Fixed-point and floating-point number representations, comparison	1
4.2	Truncation and rounding errors	1
4.3	Quantization noise, derivation for quantization noise power, coefficient quantization error, product quantization error	2
4.4	Overflow error, round-off noise power	1
4.5	Limit cycle oscillations due to product quantization and overflow errors, signal scaling	1
	Module 5: Multi-rate Digital Signal Processing, Introduction to DSP Processors	7
5.1	Decimation and interpolation - time domain and frequency domain interpretation	1
5.2	Anti-imaging filter	1
5.3	Harvard architecture	1
5.4	Multiply Accumulate Unit, pipelining, architecture of TMS320C50 digital signal processor	2
5.5	Addressing modes	1

5.6	Simple programs - arithmetic operations, wave- form generations	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Compute the DFT of the sequence $x(n) = \{1, 2, 3, 4\}$ and verify the result using the FFT algorithm.
2. A discrete-time signal $x(n)$ has length $N = 8$. Explain how the Radix-2 FFT algorithm can be used to compute its DFT and determine the computational savings compared to direct DFT computation.
3. Explain how the DFT can be used for frequency-domain analysis of discrete-time systems. Illustrate with an example.

Course Outcome 2 (CO 2)

1. Design a Butterworth low-pass digital filter using the bilinear transformation method for the given specifications.
2. Explain the procedure for designing an IIR filter from an analog prototype filter.
3. Describe warping effect in bilinear transformation method and how can we eliminate it?

Course Outcome 3 (CO 3)

1. Design a linear phase FIR low-pass filter using the Hamming window for given specifications.
2. Explain the window method for FIR filter design and design a high-pass FIR filter for a specified cutoff frequency.
3. Draw the direct form realization of FIR system.

Course Outcome 4 (CO 4)

1. Explain the finite word length effects in digital filters and discuss the different types of quantization errors.
2. Explain truncation and rounding errors with suitable examples in DSP systems.

3. Discuss the causes and effects of limit cycle oscillations in digital filters.

Course Outcome 5 (CO 5)

1. A discrete-time signal $x(n)$ is downsampled by a factor of 2. Determine the output sequence $y(n)$ and explain the effect of downsampling on the frequency spectrum. Also indicate how aliasing can be avoided.
2. A signal $x(n)$ is upsampled by a factor of 3. Determine the output sequence $y(n)$ and sketch the frequency spectrum before and after upsampling. Explain how an interpolation filter can be used to remove spectral images.
3. Using the architecture of a DSP processor, explain how the MAC unit and pipelining can be utilized to efficiently implement convolution or FIR filtering.

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EE4P45

Course Name: : DIGITAL SIGNAL PROCESSING

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Give any three properties of DFT.
2. Discuss the need for FFT. Justify your answer in terms of computational complexity and memory requirement.
3. Describe warping effect in bilinear transformation method and how can we eliminate it?
4. Calculate the number of multiplications, additions and delay elements required in the direct form II realization of the following system. $y(n) = 0.5y(n-1) - 0.25y(n-2) + x(n) + x(n-1)$
5. Draw the direct form realization of FIR system.
6. What is a linear phase filter? What conditions are to be satisfied by an FIR filter in order to have linear phase?
7. What is the range of Mantissa in floating point representation? Find the floating point representation of the number 1.5.
8. Differentiate between truncation and rounding?
9. What is multi-rate signal processing? Obtain interpolated and decimated versions for the sequence $x[n] = \{1, 2, 3, 4, 5, 6, 7, 8\}$ by a factor 2.
10. Explain the Harvard architecture used in DSP processors.

PART B

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

11. Derive the Decimation in Time algorithm for Fast Fourier transform. Find the DFT of $[3, 4, 8, 1]$ using the above method. (14 Marks)

OR

12. (a) State the following properties of DFT (i) Linearity (ii) Time Reversal (iii) Parseval's theorem. (6 marks)
- (b) Illustrate the concept of circular convolution property of a DFT sequence for the discrete time sequences $x[n] = \{1, 2, 1, 2\}$, $h[n] = \{2, 4, 6, 8\}$. (8 marks)
13. (a) Design an analog Butterworth filter that has $-1dB$ pass band attenuation at $200Hz$ and at least $-15dB$ stop band attenuation at $540Hz$. Sampling frequency = $2000Hz$. Find the cut off frequency by matching pass band criterion. Use prewarping analog frequencies for the design. (9 marks)
- (b) Apply impulse invariance transformation to $H(s) = \frac{2}{(s+1)(s+2)}$ with $T = 1sec$ and find $H(z)$. (5 marks)

OR

14. (a) Realize the system given by the difference equation $y(n) = -\frac{1}{4}y(n-1) + \frac{1}{8}y(n-2) + x(n) - 2x(n-1) + x(n-2)$ in cascade form and parallel form. (9 marks)
- (b) Obtain the direct form-II structure for the system $y(n) = 2y(n-1) + 3y(n-2) + x(n) + 2x(n-1) + 3x(n-2)$ (5 marks)
15. Obtain the following realizations for the given FIR filter. (i) Direct form realization with minimum number of multipliers (ii) Cascade realization with minimum number of multipliers

$$H(z) = \left(\frac{1}{2} + z^{-1} + \frac{1}{2}z^{-2} \right) \left(1 + \frac{1}{3}z^{-1} + z^{-2} \right)$$

(14 marks)

OR

16. (a) Design an ideal high pass filter with desired frequency response

$$H(e^{j\omega}) = 1 \text{ for } 0.25\pi \leq |\omega| \leq \pi$$

$$H(e^{j\omega}) = 0 \text{ for } |\omega| \leq 0.25\pi$$

Find $h(n)$ for $N = 11$. (use Hamming window). (9 marks)

- (b) Show that the zeros of linear phase FIR filter exists as reciprocals. (5 marks)

17. (a) Derive the quantization noise variance for uniform quantization. (6 marks)
- (b) Explain signal scaling techniques used to avoid overflow. (8 marks)

OR

18. (a) Derive the expression for quantization noise power in a DSP system. (8 marks)
- (b) A signal is quantized with b bits. Determine the quantization step size and noise power. (6 marks)
19. (a) Describe the addressing modes of the TMS320C50 DSP processor. (8 marks)
- (b) Write a program to generate a square waveform using DSP processor (6 marks)

OR

20. (a) Draw the block diagram of TMS320C50 and briefly explain the function of each block. (10 marks)
- (b) MAC is the heart of DSP processor. Justify. (4 marks)

B24EE4P46	COMPUTER NETWORKS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course aims to equip the students with an understanding of the fundamental principles of computer networks. It provides a comprehensive explanation of computer networks, layered architecture, routing and congestion control mechanisms. Students will get an overview of IP addressing, routing protocols, and the services offered by transport and application layers.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain computer networks, layered architecture, protocols and physical media used for setting up a network. (Cognitive Knowledge Level: Understand)
CO 2	Identify the role of Data link layer, role of the MAC sub layer and networking devices in Ethernets and wireless LANs. (Cognitive Knowledge Level: Apply)
CO 3	Describe routing algorithms and congestion control algorithms and ways to achieve good quality of service. (Cognitive Knowledge Level: Apply)
CO 4	Illustrate the IP address classes, ICMP protocols and other external routing protocols. (Cognitive Knowledge Level: Understand)
CO 5	Explain the services provided by the transport layer and application layer. (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	2	1		1	1	1		1
CO 2	3	2	1	2	1		1	1	1		1
CO 3	3	2	1	2	1		1	1	1		1
CO 4	3	1	1	2	1		1	1	1		1
CO 5	3	1	1	2	1	1	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	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 (7 hours)

Introduction to Computer Networks

Introduction to computer networks, network hardware, network software - protocol hierarchies - design issues for the layers - connection oriented versus connectionless service, reference models - OSI reference model, TCP/IP reference model, comparison of OSI and TCP/IP reference models.

Physical Layer

Transmission media overview - twisted pair and fiber optics, performance indicators - bandwidth, throughput, latency, bandwidth-delay product.

MODULE 2 (8 hours)

Data Link Layer

Data link layer - data link layer design issues, error detection and correction, sliding window Protocols, Medium Access Control (MAC) sublayer, channel allocation problem, multiple access protocols - CSMA, collision free protocols, ethernet - switched ethernet, fast ethernet and gigabit ethernet, wireless LANs - 802.11 - architecture and protocol stack, use of bridges, repeaters, hubs, switches, routers and gateways.

MODULE 3 (7 hours)

Network Layer

Network layer design issues. routing algorithms - the optimality principle, shortest path routing, flooding, distance vector routing, link state routing, routing for mobile hosts. congestion control algorithms - approaches to congestion control (basic concepts only). Quality of Service (QoS) - requirements, techniques for achieving good QoS - traffic shaping, packet scheduling.

MODULE 4 (7 hours)

Network Layer in the Internet

IPv4 protocol, IP addresses, IPv6, internet control protocols - Internet Control Message Protocol (ICMP), Address Resolution Protocol (ARP), Dynamic Host Configuration Protocol (DHCP), Open Shortest Path First (OSPF) Protocol, Border Gateway Protocol (BGP). Internet multicasting.

MODULE 5 (7 hours)

Transport Layer and Application Layer

Transport service - services provided to the upper layers, transport service primitives, User Datagram Protocol (UDP) - introduction, remote procedure call. Transmission Control Protocol (TCP) - introduction, TCP service model, TCP protocol, TCP segment header, connection establishment and release.

Application Layer - Domain Name System (DNS) - overview of DNS name space and Name servers, Electronic mail - Architecture and services - SMTP, IMAP, POP3.

World Wide Web (WWW) - Architectural overview, HTTP, File Transfer Protocol (FTP).

Text Books

1. Andrew S. Tanenbaum, *Computer Networks*, Pearson Education India, 4th ed., 2008.
2. Behrouz A Forouzan, *Data Communication and Networking*, McGraw-Hill Education, 5th ed.

Reference Books

1. Larry L Peterson and Bruce S Dave, *Computer Networks – A Systems Approach*, 5th ed.
2. James F. Kurose, Keith W. Ross, *Computer Networking: A Top-Down Approach*, 6th ed., 2011.
3. W. Richard Stevens *TCP/IP*, Illustrated Volume 1, Addison-Wesley, 2005.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Computer Networks and Physical Layer	7
1.1	Introduction - uses of computer networks	1
1.2	Network hardware	1
1.3	Network software - protocol hierarchies - Design issues for the layers - Connection oriented versus connectionless service	1
1.4	Reference models - the OSI reference model, the TCP/IP reference model s	1

1.5	Reference models, comparison of OSI and TCP/IP reference models	1
1.6	Physical Layer - transmission media overview - twisted pair and fiber optics	1
1.7	Performance indicators - bandwidth, throughput, latency, bandwidth–delay product	1
	Module 2: Data Link Layer	8
2.1	Data link layer - data link layer design issues	1
2.2	Error detection and correction	1
2.3	Sliding window protocols	1
2.4	Medium Access Control (MAC) sublayer	1
2.5	Channel allocation problem, multiple access protocols – CSMA	1
2.6	Collision free protocols	1
2.7	Ethernet – switched ethernet, fast ethernet and gigabit ethernet, Wireless LANs - 802.11 – architecture and protocol stack	1
2.8	Use of bridges, repeaters, hubs, switches, routers and gateways	1
	Module 3: Network Layer	7
3.1	Network layer design issues	1
3.2	Routing algorithms, the optimality principle, shortest path routing, flooding	1
3.3	Distance vector routing	1
3.4	Link state routing	1
3.5	Routing for mobile hosts, congestion control algorithms – approaches to congestion control (Details not required)	1
3.6	Quality of Service (QoS) - requirements, techniques for achieving good QoS - traffic shaping, packet scheduling	2
	Module 4: Network Layer in the Internet	7
4.1	Internet Protocol (IP) - IPv4 protocol	1
4.2	IP addresses	1
4.3	IPv6	1
4.4	Internet control protocols - Internet Control Message Protocol (ICMP), Address Resolution Protocol (ARP), Dynamic Host Configuration Protocol (DHCP)	2
4.5	Open Shortest Path First (OSPF) protocol	1
4.6	Border Gateway Protocol (BGP), internet multicasting	1
	Module 5: Transport Layer and Application Layer	7
5.1	Transport service - services provided to the upper layers transport service primitives	1
5.2	User Datagram Protocol (UDP) - introduction, remote procedure call	1
5.3	Transmission Control Protocol (TCP) – introduction, TCP service model, TCP protocol	1
5.4	TCP segment header, Connection establishment and release	1

5.5	Application layer - Domain Name System (DNS) - overview of DNS name space and Name servers	1
5.6	Electronic mail - architecture and services - SMTP, IMAP, POP3	1
5.7	World Wide Web (WWW) - architectural overview, HTTP, File Transfer Protocol (FTP)	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Compare the OSI and TCP/IP reference model.
2. Distinguish between Connection oriented and connectionless service .
3. Explain various performance indicators of computer networks.

Course Outcome 2 (CO 2)

1. Explain the role of the Data link layer in computer networks.
2. Illustrate the sliding window protocol for error detection and correction.
3. Explain the use of Switches, Routers and Gateways.

Course Outcome 3 (CO 3)

1. What is flooding?
2. Discuss how congestion control is done in computer networks.
3. What is meant by Quality of service? How can it be improved?

Course Outcome 4 (CO 4)

1. Describe the format of IPv4/IPv6 datagram with the help of a diagram, highlighting the significance of each field.
2. Explain Subnetting with an example.
3. Illustrate Open Shortest Path First (OSPF) Protocol and Border Gateway Protocol (BGP).

Course Outcome 5 (CO 5)

1. Explain the UDP/TCP protocol.
2. Describe how message transfer is done using SMTP.
3. Discuss the security issues of FTP. How can it be improved?



MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EE4P46

Course Name: : COMPUTER NETWORKS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What is a VPN ?
2. Discuss why fiber optic is preferred over copper wires, when you want to get higher bandwidth in the range of 100Mbps or higher.
3. What is the need for framing?
4. What is piggybacking?
5. Compare adaptive routing algorithms with the non-adaptive type.
6. Describe jitter and discuss how it can affect various data transfer applications.
7. What is the urgent need for migrating to IPv6 from IPv4?
8. Illustrate Address Resolution Protocol.
9. What is the use of DNS?
10. What is FTP and discuss its security concerns.

PART B

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

11. (a) Explain OSI reference model with a neat diagram. (7 marks)
(b) Discuss about WAN networks. (7 marks)

OR

12. (a) Explain various performance indicators of computer networks. (7 marks)
(b) What is a computer network? Explain any 4 applications of computer networks. (7 marks)
13. (a) Illustrate any two Collision free Protocols. (8 marks)
(b) Describe the use of Switches, Routers and Gateways. (6 marks)

OR

14. (a) Explain the working of IEEE 802.11 wireless LAN with suitable diagrams. (8 marks)
(b) Explain the role of the Data link layer in computer networks. (6 marks)
15. (a) Explain distance vector routing with an example. (7 marks)
(b) What is count to infinity problem in Distance Vector Routing? (7 marks)

OR

16. (a) Explain link state routing. (8 marks)
(b) What is meant by Quality of service? How can it be improved? (6 marks)
17. (a) Explain Border Gateway Protocol (BGP). (8 marks)
(b) List and explain the different types of error reporting messages used by ICMP. (6 marks)

OR

18. Describe the format of IPv4 datagram with the help of a diagram, highlighting the significance of each field. (14 marks)
19. Explain how message transfer is done using SMTP. (14 marks)

OR

20. (a) Explain the format of TCP segment. (8 marks)
(b) Write a short note on Remote Procedure Call (RPC). (6 marks)

The logo of Mar Athanasius College of Engineering is a large, faint watermark in the background. It features a circular gear-like border. Inside the circle is a light blue field with a large orange cross. Below the cross is a green field. At the bottom of the circle is a pink base. A yellow banner at the bottom of the logo contains the text 'KNOWLEDGE IS POWER' in a serif font.

OPEN ELECTIVE II

B24EE4G21	BIOMEDICAL IN-STRUMENTATION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4		

Preamble

This course provides an in depth understanding of biomedical instrumentation and the physiological principles underlying the generation and measurement of biological signals. It introduces various medical instruments used for diagnosis and monitoring, as well as modern developments such as imaging systems, telemedicine, and medical robotics. The course enables students to integrate engineering principles with medical science in the design and development of biomedical systems for healthcare applications.

Prerequisites

Nil

Course Outcomes

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

CO 1	Describe basic human physiological systems and the principles of bioelectric signal generation. (Cognitive Knowledge Level: Understand)
CO 2	Understand the physiological principles of blood pressure monitoring systems and cardiac mechanical activity measurement. (Cognitive Knowledge Level: Understand)
CO 3	Apply suitable biomedical instrumentation techniques to measure EEG, EMG, and respiratory parameters. (Cognitive Knowledge Level: Apply)
CO 4	Explain the fundamental principles of modern imaging systems and therapeutic equipments used in medical diagnostics. (Cognitive Knowledge Level: Understand)
CO 5	Illustrate the operating principles of contemporary healthcare technologies and essential electrical safety practices. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

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

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/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 (7 hours)

Human Physiological Systems

Heart and cardiovascular system, physiology of the respiratory system, anatomy of the nervous and muscular systems.

Bioelectric Signals and Electrodes

Bioelectric potential, resting and action potential, generation and propagation, bioelectric potentials associated with ECG, EEG and EMG. Bio potential electrodes - surface electrode, microelectrode, needle electrodes.

MODULE 2 (8 hours)

Measurement of Blood Pressure

Direct and indirect measurement - oscillometric method, ultrasonic method. Measurement of blood flow and cardiac output - plethysmography, Measurement of heart sounds - phonocardiography.

Cardiac Measurements

Electro-conduction system of the heart, electrocardiography, electrodes and leads, Einthoven Triangle, ECG read out devices, ECG machine - block diagram.

MODULE 3 (8 hours)

Measurements from the Nervous System

Neuronal communication, EEG waveforms and features, 10-20 electrode measurement, block diagram of EEG signal acquisition system - brain computer interfacing.

Muscle Response and Respiratory Parameters

Electromyography - block diagram of EMG recorders, nerve conduction velocity measurement. Respiratory parameters measurements-spirometer, pneumograph.

MODULE 4 (7 hours)

Modern Imaging Systems

Basic X-ray machines, Computed Tomography (CT), Magnetic Resonance Imaging (MRI)

and ultrasound imaging.

Therapeutic Equipments

Cardiac pacemakers, defibrillators, haemodialysis machines, artificial kidneys, lithotripsy shortwave and microwave diathermy machines, ventilators, heart-lung machines and infant incubators.

MODULE 5 (6 hours)

Emerging Technologies in Healthcare

Telemedicine, applications of telemonitoring, introduction to medical robotics, AI in the medical field.

Electrical Safety

Physiological effects of electric current, shock hazards from electrical equipment, methods of accident prevention.

Text Books

1. L. Cromwell, F. J. Weibell and L. A. Pfeiffer, *Biomedical Instrumentation Measurements*, Pearson Education, 2nd ed., 1990.
2. J. G. Webster, *Medical Instrumentation, Application and Design*, John Wiley and Sons, 5th ed., 2020.
3. R. S. Khandpur, *Handbook of Biomedical Instrumentation*, Tata McGraw Hill, 3rd ed., 2014.

Reference Books

1. J. J. Carr and J. M. Brown, *Introduction to Biomedical Equipment Technology*, Pearson Education, 4th ed., 2000.
2. Achim Schweikard, *Medical Robotics*, 1st ed., Springer 2015.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Human Physiological Systems	7
1.1	Heart and cardiovascular system, physiology of the respiratory system	1
1.2	Anatomy of the nervous and muscular systems	1
1.3	Problems encountered in measuring living systems	1
	Bioelectric Signals and Electrodes	
1.4	Bioelectric potential, resting and action potential, generation and propagation	1
1.5	Bioelectric potentials associated with physiological systems (ECG, EEG and EMG)	1
1.6	Noise and artefacts in biological signals and their management	1
1.7	Bio potential Electrodes - surface electrode, microelectrode, needle electrodes	1
	Module 2: Measurement of Blood Pressure	8
2.1	Direct and indirect measurement	1
2.2	Oscillometric method	1
2.3	Ultrasonic method	1
2.4	Measurement of blood flow and cardiac output - plethysmography	1
2.5	Measurement of heart sounds - phonocardiography	1
	Cardiac Measurements	
2.6	Electro-conduction system of the heart, electrocardiography	1
2.7	Einthoven Triangle, ECG read out devices	1
2.8	ECG machine - block diagram	1
	Module 3: Measurements from the Nervous System	8
3.1	Neuronal communication	1
3.2	EEG waveforms and Features	1
3.3	10-20 electrode measurement	1
3.4	Block diagram of EEG signal acquisition system – Brain-Computer interfacing	1
	Muscle Response and Respiratory Parameters	
3.5	Electromyography, Block diagram of EMG recorders	1
3.6	Nerve conduction velocity measurement	1
3.7	Spirometer	1
3.8	Pneumograph	1
	Module 4: Modern Imaging Systems	7
4.1	Basic X-ray machines, Computed Tomography (CT)	1
4.2	Magnetic Resonance Imaging (MRI)	1

4.3	Ultrasound imaging.	1
	Therapeutic Equipments	
4.4	Cardiac pacemakers, defibrillators	1
4.5	Haemodialysis machines, artificial kidneys, lithotripsy	1
4.6	Shortwave and microwave diathermy machines, ventilator	1
4.7	Heart-lung machines and infant incubators	1
	Module 5: Emerging Technologies in Healthcare	6
5.1	Telemedicine, applications in telemonitoring	1
5.2	Introduction to medical robotics	1
5.3	AI in the medical field	1
	Electrical Safety	
5.4	Physiological effects of electric current	1
5.5	Shock hazards from electrical equipment	1
5.6	Methods of accident prevention.	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the anatomy of the heart and cardiac system.
2. Describe the physiology of the respiratory system.
3. Discuss the generation and propagation of action potential with neat sketches.

Course Outcome 2 (CO 2)

1. Explain the direct method of blood pressure measurement.
2. Explain the oscillometric method of blood pressure measurement.
3. Explain the measurement of cardiac output.

Course Outcome 3 (CO 3)

1. Explain the 10-20 system of EEG electrodes placement.
2. Draw and explain the block diagram of EMG recorder.
3. Explain the measurement of respiratory parameters using spirometer.

Course Outcome 4 (CO 4)

1. Explain the principle of MRI scanning.
2. Explain demand pacemaker with a neat block diagram.
3. Explain artificial kidney with neat sketches.

Course Outcome 5 (CO 5)

1. Draw the block diagram of a telemetry system.
2. Explain the steps involved in AI-based medical image analysis for disease detection.
3. What are the different methods of accident prevention in hospitals?

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EE4G21

Course Name: : BIOMEDICAL INSTRUMENTATION

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Discuss the functional of respiratory system.
2. What are the different bioelectrical potentials generated in human body?
3. What is blood pressure? How it is measured?
4. Explain Einthoven triangle.
5. With neat sketches, explain the block diagram of EMG.
6. Explain the 10-20 system of EEG electrode placement.
7. Explain the basic principle of the ultrasonic imaging system.
8. Explain microwave diathermy.
9. What do you mean by telemedicine?
10. Differentiate between macro shock and micro shock.

PART B

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

11. (a) Discuss the problems encountered in measurement on biological systems. (7 marks)
(b) Classify the types of surface electrodes in detail. (7 marks)

OR

12. (a) Explain the equivalent circuit of the bio-potential electrode interface. (8 marks)
(b) Write a short note on i) resting potential, ii) action potentials. (6 marks)
13. (a) With the help of a neat diagram, explain phonocardiography. (7 marks)
(b) Explain with the help of a neat diagram, impedance plethysmograph for measurement of blood flow. (7 marks)

OR

14. Explain in detail with neat sketches, explain the different electrode placement schemes of ECG and its block diagram. (14 marks)
15. (a) Draw the different EEG waveforms and state their frequency. (7 marks)
(b) Draw and explain the block diagram of the EEG machine. (7 marks)

OR

16. (a) Explain in detail about neuronal communication. (7 marks)
(b) Describe the measurement of respiratory parameters using a spirometer. (7 marks)
17. (a) Explain the principle of MRI scanning. (7 marks)
(b) Illustrate the principle of CT scanning. (7 marks)

OR

18. (a) Mention different types of ventilators and write brief notes on the biomedical applications. (7 marks)
(b) Discuss in detail about cardiac pacemakers. (7 marks)
19. Explain in detail about medical robotics and scope of AI on medical field. (14 marks)

OR

20. Explain physiological effects of electric currents and write brief notes on various susceptibility parameters. (14 marks)

B24EE4G22	INTRODUCTION TO ENERGY STORAGE SYSTEMS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	2	3	2024

Preamble

The course aims to provide a comprehensive understanding of energy storage systems and their vital role in enhancing reliability, stability, and power quality in modern power systems with high renewable energy penetration. It covers the principles, modeling, operation, and economic aspects of mechanical, thermal, chemical, electrochemical, and electromagnetic energy storage technologies. The course also addresses renewable energy integration, smart grids, and electromobility, enabling students to analyze and apply suitable storage solutions in both isolated and grid-connected power systems.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the role of energy storage in power system. (Cognitive Knowledge Level: Understand)
CO 2	Explain mechanical energy storage technologies and their applications. (Cognitive Knowledge Level: Understand)
CO 3	Illustrate thermal, chemical energy storage technologies. (Cognitive Knowledge Level: Understand)
CO 4	Explain and analyze electrochemical, capacitor-based, and superconducting magnetic energy storage systems. (Cognitive Knowledge Level- Understand)
CO 5	Illustrate the role of energy storage technologies in integrating renewable energy sources and enabling smart grid applications. (Cognitive Knowledge Level- Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	30	30	30
Understand	70	70	40
Apply			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 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 (6 hours)

Necessity and Functional Role of Energy Storage Systems

Need and importance of energy storage in modern power systems, trends in power system development- demand side characteristics, supply side characteristics, meeting the load, energy and power balance in a storage unit, mathematical modeling of Energy Storage Systems (ESS) - modeling of the power transformation system (PTS), central storage (CS), and charge-discharge control system (CDCS), econometric model of storage, storage applications - static duties of storage plant, dynamic duties of storage plant.

MODULE 2 (7 hours)

Mechanical Energy Storage

Pumped hydro storage - general considerations, power extraction system, central store for pumped hydro, compressed air energy storage - general considerations, basic principles, central store, power extraction system, despatch and economic limitations, flywheel storage - general consideration, flywheel as a central store, applications.

MODULE 3 (6 hours)

Thermal and Chemical Energy Storages

Thermal energy storage - general considerations, storage media - sensible and latent heat, phase change materials, containments, power extraction, thermal energy storage in a power plant, economic evaluation. Hydrogen and other synthetic fuels - general considerations, synthetic storage media, hydrogen production, storage containment for hydrogen, hydride concept.

MODULE 4 (8 hours)

Electrochemical Energy Storage

General considerations, primary vs secondary batteries, battery parameters - C-rating, SoC, DoD, specific energy, specific power. Fuel cells - schematic diagram of an electrochemical fuel cell, thermal regime, power extraction system. Capacitor bank storage – capacitor storage media, power extraction.

Superconducting Magnetic Energy Storage

Basic principles, superconducting coils, cryogenic systems, power extraction, environmental and safety problems.

MODULE 5 (9 hours)

Renewable Energy Technologies and Smart Power Systems

Types of renewable power sources - wave, wind, tidal, small scale hydroelectric energy sources, solar thermal technologies and photovoltaics.

Microgrid - concept, types, challenges and disadvantages, smart grid-definitions, characteristics, components, benefits, challenges, smart meter, smart sensor, SCADA.

Text Books

1. A.G. Ter-Gazarian, *Energy Storage for Power Systems.*, The Institution of Engineering and Technology (IET) Publication, 3rd ed., 2020.
2. Mehrdad Ehsani, Yimin Gao and Ali Emadi Modern Electric, *Hybrid Electric, and Fuel Cell Vehicles*, CRC Press, 2nd ed., 2010.
3. Francisco Diaz-Gonzalez, Andreas Sumper, Oriol Gomis-Bellmunt, *Energy Storage in Power Systems* , Wiley Publication, ISBN:978-1-118-97130-7,2016.
4. Dr. Dileep G, *Smart grid components and applications*,Edberrys publications,1st ed., 2019.
5. Iqbal Hussein *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 4th ed., 2010.

Reference Books

1. Lars T. Berger and Krzysztof and Krzysztof Iniewski , *Smart grid Applications, Communications, and Security*, Wiley publications,2nd ed.,2018.
2. Dr. Dileep G, *Distributed generation and smart grid*, Advay publications,1st ed.,2018.
3. Electric Power Institute (USA), *Electricity Energy storage technology options: A White Paper Primer on Applications*, TCosts, and Benefits (1020676), December 2010.
4. Paul Denholm, Erik Ela, Brendan Kirby and Michael Milligan, *The role of energy storage with renewable electricity generation*,National Renewable Energy Laboratory (NREL).
5. P. Nezamabadi and G.B. Gharehpetian, *Electrical energy management of virtual power plants in distribution networks with renewable energy resources and energy storage systems*,IEEE Power Distribution Conference,2011.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Necessity and Functional Role of Energy Storage Systems	6
1.1	Need and importance of energy storage in modern power systems, trends in power system development- demand side characteristics, supply side characteristics, meeting the load	1
1.2	Energy and power balance in a storage unit - schematic structure of energy storage	1
1.3	Mathematical modeling of Energy Storage Systems (ESS) - modeling of the power transformation system (PTS), central storage (CS), and charge-discharge control system (CDCS)	2
1.4	Econometric model of storage - annual cost of storage facility	1
1.5	Storage applications - static duties of storage plant, dynamic duties of storage plant	1
	Module 2: Mechanical Energy Storage	7
2.1	Pumped hydro storage - general considerations	2
2.2	Power extraction system, central store for pumped hydro	1
2.3	Compressed air energy storage - general considerations, basic principles	1
2.4	Central store, power extraction system, despatch and economic limitations	1
2.5	Flywheel storage - general consideration, flywheel as a central store, applications	2
	Module 3: Thermal and Chemical Energy Storages	6
3.1	Thermal energy storage - general considerations	1
3.2	Storage media - sensible and latent heat, phase change materials	1
3.3	Containments, power extraction, thermal energy storage in a power plant, economic evaluation	1
3.4	Hydrogen and other synthetic fuels - general considerations	1
3.4	Synthetic storage media, hydrogen production	1
3.5	Storage containment for hydrogen, hydride concept	1
	Module 4: Electrochemical Energy Storage	8
4.1	General considerations, primary vs secondary batteries	1
4.2	Battery parameters - C-rating, SoC, DoD, specific energy, specific power	1
4.3	Fuel cells - schematic diagram of an electrochemical fuel cell, thermal regime, power extraction system	2

4.4	Capacitor bank storage – capacitor storage media, power extraction	1
	Superconducting magnetic energy storage	
4.5	Superconducting magnetic energy storage - basic principles, superconducting coils, cryogenic systems	2
4.6	Power extraction, environmental and safety problems	1
	Module 5: Renewable Energy Technologies and Smart Power Systems	9
5.1	Types of renewable power sources - wave, wind, tidal	2
5.2	Small scale hydroelectric energy sources	1
5.3	Solar thermal technologies and photovoltaics	1
5.4	Microgrid - concept, types, challenges and disadvantages	2
5.5	Smart grid-definitions, characteristics, components, benefits, challenges	2
5.6	Smart meter, smart sensor, SCADA	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. What are the different parts of a complete energy storage unit?.
2. Derive the mathematical modeling of a energy storage system.
3. Explain static and dynamic duty of storage plant.

Course Outcome 2 (CO 2)

1. Explain the working of pumped hydro energy storage.
2. Describe the working of compressed air energy storage system.
3. List the applications of flywheel energy storage.

Course Outcome 3 (CO 3)

1. List the applications of thermal energy storage systems.
2. Explain sensible heat storage and latent heat storage.
3. What are the different storage containment of hydrogen?

Course Outcome 4 (CO 4)

1. Explain the working of fuel cell along with schematic diagram.
2. Explain the battery parameters.
3. Define Superconducting Magnetic Energy Storage

Course Outcome 5 (CO 5)

1. Explain small-scale hydroelectric energy.
2. What are the different types of renewable power sources?
3. Explain the characteristics of smart grid systems.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EE4G22

Course Name: : INTRODUCTION TO ENERGY STORAGE SYSTEMS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the importance of energy storage system in modern power systems.
2. Discuss the role of CDCS in an energy storage system.
3. Mention two applications of flywheel energy storage systems.
4. How does CAES differ from pumped hydro in terms of energy conversion?
5. Define the hydride concept in hydrogen storage.
6. Differentiate between sensible heat and latent heat storage media.
7. Explain the difference between State of Charge and Depth of Discharge.
8. Describe primary and secondary batteries.
9. Discuss the advantages of smart grid implementation.
10. Explain the different types of renewable energy sources.

PART B

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

11. (a) Discuss static and dynamic duties of energy storage plant. (7 marks)
(b) With neat diagram explain energy and power balance in a storage unit. (7 marks)

OR

12. (a) Explain the econometric model of energy storage. Derive the expression for annual cost of the system. (8 marks)
- (b) Discuss the terms i) charge efficiency ii) storage efficiency iii) discharge efficiency. (6 marks)
13. (a) Describe the basic principle of compressed air energy storage. Explain the central storage system and power extraction system used in CAES plants. (10 marks)
- (b) Discuss how a flywheel acts as a central store for energy. (4 marks)

OR

14. (a) Discuss the working principle of pumped hydro electric storage system with neat diagram. (7 marks)
- (b) Describe the role of motor-generator in flywheel storage. (7 marks)
15. (a) Discuss the containment methods for thermal energy storage systems. (8 marks)
- (b) Explain the methods to produce hydrogen. (6 marks)

OR

16. Explain the principle of operation of thermal energy storage systems, including how energy is stored and released. (14 marks).
17. (a) With a neat labelled diagram and suitable equations explain the working of fuel cell. (8 marks)
- (b) Explain the principle of energy storage in a capacitor bank. (6 marks)

OR

18. (a) Describe basic principle and working of superconducting magnetic energy storage system. (6 marks)
- (b) Explain the terms i) battery C-rate, ii) specific energy iii) specific power iv) battery efficiency. (8 marks)
19. (a) Write short notes on tidal energy conversion system. (7 marks)
- (b) With a neat labelled diagram explain the main components and working of a Battery SCADA system. (7 marks)

OR

20. (a) Briefly discuss small scale hydroelectric energy system. (7 marks)
- (b) Describe the concept of Smart House. (7 marks)

B24EE4G23	ILLUMINATION ENGINEERING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The aim of this course is to impart fundamental and applied knowledge of illumination engineering for efficient lighting design. The course covers light sources, photometric quantities, interior and exterior lighting design, aesthetic lighting, daylighting, and applications. By the end of the course, students will be able to analyze lighting requirements, design sustainable and energy-efficient lighting systems in accordance with standards and practical considerations.

Prerequisites

NIL

Course Outcomes

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

CO 1	Explain the fundamentals of light, types of illumination, lighting systems, characteristics of light sources, and quality aspects of good lighting. (Cognitive Knowledge Level: Understand)
CO 2	Apply photometric quantities to perform basic illumination and luminance calculations using laws of illumination and photometric measurements. (Cognitive Knowledge Level: Apply)
CO 3	Design interior lighting systems by selecting appropriate lamps, fixtures, and illumination levels in accordance with Indian standards. (Cognitive Knowledge Level: Apply)
CO 4	Design exterior lighting systems including road, flood, and sports lighting while considering glare, safety, and performance requirements. (Cognitive Knowledge Level: Apply)
CO 5	Understand the concepts of aesthetic lighting, emergency lighting, lighting control systems, daylighting strategies, human-centric lighting and illumination in aviation for sustainable lighting solutions. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	2	1	1	1		1		1
CO 2	3	2	2	2	2	2	1	1	1	1	1
CO 3	3	2	3	2	1	2	1		1		1
CO 4	3	2	2	2	1	2	1		1		1
CO 5	3	2	1	2	1	2	1	1	1		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/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 (7 hours)

Introduction of Light

Nature of light, types of illumination - daylighting and artificial lighting, quality of good lighting, light sources - incandescent, halogen, fluorescent, mercury vapour, metal halide, sodium vapour lamps (LPSV & HPSV), LED lamps and modern trends, lighting systems - direct, indirect, semi-direct and semi-indirect, lighting effects - glare, shadow, reflection, colour rendering and stroboscopic effect.

MODULE 2 (7 hours)

Photometric Quantities

Luminous flux, luminous intensity, illuminance, luminance, luminous efficacy, relations between photometric quantities, laws of illumination and basic illuminance calculations, polar curves, light measurement - goniometer, integrating sphere and lux meter, evaluation of total luminous flux. Numerical problems.

MODULE 3 (7 hours)

Interior Lighting Design

Illumination requirements for various work planes, types of luminaires and basic terms - DLOR and ULOR, maintenance factor, utilisation factor, reflection factor, uniformity ratio, selection of lamps and luminaires, lumen method for interior lighting design - numerical problems, Indian standards and recommended illumination levels.

MODULE 4 (8 hours)

Exterior Lighting Design

Objectives and requirements of exterior lighting, road lighting - objectives, glare, road surface reflection, basic arrangements and lighting schemes, basic design, flood lighting - objectives, beam spread, waste light factor, depreciation factor, basic design, sports lighting - objectives and important design parameters. Numerical problems.

MODULE 5 (7 hours)

Aesthetic Lighting, Human-Centric Lighting and Aviation Applications

Aesthetic lighting - monument, façade and landscape lighting - concepts, emergency lighting

- basic requirements, lighting controls - dimmers, motion sensors, occupancy sensors, photo sensors, importance of daylighting, daylighting strategies - windows, skylights, roof systems, advantages and limitations of daylighting, human-centric lighting - concepts, applications of illumination in aviation - cockpit lighting, aircraft cabin lighting, exterior aircraft lighting.

Text Books

1. M.A. Cayless & A.M. Marsdon, *Lamps & Lighting*, Oxford & IBH publishing company, 4th ed., 1996.
2. D. C. Pritchard, *Lighting*, Routledge, Taylor & Francis Group, 6th ed., 2016,
3. D.W. Durrant, *Interior Lighting Design*, Lighting Industry Federation Ltd, London, 5th ed., 1977.
4. Jack L. Lindsey, *Applied Illumination Engineering*, McGraw-Hill Book Company, 3rd ed., 2013

Reference Books

1. J. B. Gupta, *Utilization of Electrical Energy and Electric Traction*, S. K. Kataria & Sons, New Delhi, 10th ed., 2013
2. *IES Lighting Recommended Practices*, Illuminating Engineering Society
3. Craig DiLouie, *Advanced Lighting Controls: Energy Savings, Productivity, Technology and Applications*, CRC Press, 1st ed., 2005.
4. Robert Karlicek, *Handbook of Advanced Lighting Technology*, Springer Publications, 1st ed., 2017.
5. R. H. Simons & A. R. Bean, *Lighting Engineering Applied calculations*, Routledge, 1st ed., 2020

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction of Light	7
1.1	Nature of light, types of illumination, daylighting and artificial lighting, quality of good lighting	1
1.2	Light sources - incandescent, halogen, fluorescent, mercury vapour, metal halide	2
1.3	Sodium vapour lamps (LPSV & HPSV), LED lamps and modern trends	1

1.4	Lighting systems - direct, indirect, semi-direct and semi-indirect	1
1.5	Lighting effects - glare, shadow, reflection, colour rendering and stroboscopic effect	2
	Module 2: Photometric Quantities	7
2.1	Luminous flux, luminous intensity, illuminance, luminance, luminous efficacy	1
2.2	Relations between photometric quantities, laws of illumination	2
2.3	Basic illuminance calculations	1
2.4	Polar curves, light measurement - gonio meter, integrating sphere and lux meter	1
2.5	Evaluation of total luminous flux. Numerical problems	2
	Module 3: Interior Lighting Design	7
3.1	Illumination requirements for various work planes	1
3.2	Types of luminaires and basic terms - DLOR and ULOR	1
3.3	Maintenance factor, utilisation factor, reflection factor, uniformity ratio	1
3.4	Selection of lamps and luminaires	1
3.5	Lumen method for interior lighting design - numerical problems	2
3.6	Indian Standards and recommended illumination levels	1
	Module 4: Exterior Lighting Design	8
4.1	Objectives and requirements of exterior lighting	1
4.2	Road lighting - objectives, glare, road surface reflection	1
4.3	Road lighting - basic arrangements and lighting schemes, basic design	2
4.4	Flood lighting - objectives, beam spread, waste light factor, depreciation factor, basic design	2
4.5	Sports lighting - objectives and important design parameters. Numerical problems	2
	Module 5: Aesthetic Lighting, Human-Centric Lighting and Aviation Applications	7
5.1	Aesthetic lighting - monument, façade	1
5.2	Landscape lighting - concepts, emergency lighting – basic requirements	1
5.3	Lighting controls - dimmers, motion sensors, occupancy sensors, photo sensors	1
5.4	Importance of daylighting, daylighting strategies - windows, skylights, roof systems	1
5.5	Advantages and limitations of daylighting, human-centric lighting - concepts	1
5.6	Applications of illumination in aviation - cockpit lighting, aircraft cabin lighting, exterior aircraft lighting	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Differentiate between direct and indirect sources.
2. Explain colour rendering and stroboscopic effect.
3. List out the qualities of good lighting.

Course Outcome 2 (CO 2)

1. Problems based on total luminous flux calculation.
2. Differentiate illuminance and luminance.
3. Explain laws of illumination.

Course Outcome 3 (CO 3)

1. Problems based on lumen method to calculate the number of luminaires.
2. Define DLOR and ULOR.
3. Calculation of uniformity ratio.

Course Outcome 4 (CO 4)

1. What are the basic arrangements in road lighting?
2. Define waste light factor.
3. Numerical problems based on the design of exterior lighting.

Course Outcome 5 (CO 5)

1. Explain HCL.
2. Illustrate the different lighting control methods.
3. What are the different daylighting strategies?

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EE4G23

Course Name: : ILLUMINATION ENGINEERING

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define the terms Glare and Stroboscopic effect
2. Explain different system of artificial lighting.
3. A lamp emits 500 lumens in all directions. Calculate its MSCP.
4. Explain the working principle of an integrating sphere.
5. Define the terms maintenance factor and coefficient of utilisation.
6. Enumerate the factors to be considered while designing an indoor lighting scheme.
7. Describe the requirement of sports lighting.
8. Explain the principles employed in the design of street lighting installations.
9. Explain Human -Centric lighting and its application.
10. List the requirements of cockpit lighting.

PART B

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

11. (a) With the help of a diagram explain the working of a high-pressure sodium vapour lamp. (8 marks)
- (b) Discuss the different qualities of good lighting system. (6 marks)

OR

12. (a) Explain the necessity of supplementary artificial lighting. (5 marks)
- (b) Explain the working of a mercury vapour lamp and list out its advantages (9 marks)
13. (a) State and explain the laws of illumination. (6 marks)
- (b) The candle power of a source is 300 candela in all directions below the lamp. The mounting height of the lamp is 6 m. Find the illumination at a point:
- i. A, just below the lamp.
 - ii. B, which is 4 m horizontally away from the lamp on the ground.
 - iii. The total luminous flux in an area of 1.5 m diameter around the lamp on the ground. (10 marks)

OR

14. (a) With neat diagram explain the measurement of M.S.C.P by integrating sphere (7 marks)
- (b) Two light source each having a uniform intensity of 600 cd are mounted 8 m high and 30 m apart. Determine
- i. illumination directly underneath one lamp
 - ii. illumination at a distance midway between the lamps. (7 marks)
15. (a) Define i) Maintenance factor, ii) Uniformity ratio, iii) Direct ratio, (iv) Coefficient of Utilization. (7 marks)
- (b) An office 30 m × 15 m is illuminated by twin 40 W fluorescent luminaires of lumen output 5600 lumens. The lamps being mounted at a height of 3 m from the work place, the average illumination required is 240 lux. Calculate the number of lamps required to be fitted in the office, assuming the coefficient of utilisation to be 0.6 and maintenance factor to be 0.8. Also show the arrangements of lamps. (7 marks)

OR

16. (a) A hall of 30 × 20 m × 5 m is to be provided with a general illumination of 300 lumens/m². Determine the number of 500 W fluorescent tubes required, their spacing, mounting height, and total wattage. Take luminous efficiency of fluorescent tube as 25 lumens/W. Assume coefficient of utilization of 0.6 and depreciation factor of 1.6. (10 marks)

- (b) Define ULOR and DLOR (4 marks)
17. (a) Explain the two basic principles employed in street lighting? (8 marks)
- (b) Define the terms a) Beam spread angle b) waste light factor associated with flood lighting. (6 marks)

OR

18. (a) The boundary of a football stadium is 100 m x 50 m. Calculate the number of luminaries required to get an illumination of 600 lux. Luminaries of 1000 W with an efficiency of 90 lumen per watt are used for installation. Assume utilization factor = 0.8, light loss factor = 1.2 and maintenance factor = 0.5. Sketch the configuration of the light fittings. (9 marks)
- (b) What are the main factors to be considered while designing road lighting? (5 marks)
19. (a) Explain the need of emergency lighting and lighting controllers in a building. (7 marks)
- (b) Describe the characteristics of monument lighting (7 marks)

OR

20. (a) Explain the lighting requirements in aircraft cockpit lighting and its importance for pilot visibility. (7 marks)
- (b) Explain the importance of daylighting in buildings and discuss the various daylighting strategies used in modern architecture. (7 marks)

B24EE4G24	ARTIFICIAL NEURAL NETWORKS AND FUZZY LOGIC SYSTEMS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces the fundamental concepts of artificial neural networks and fuzzy logic systems. It covers neural models, learning algorithms, deep and convolutional networks, and fuzzy reasoning. The course focuses on handling uncertainty and learning in intelligent systems with basic engineering applications.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain basic neural models, learning concepts, and limitations of artificial neural networks. (Cognitive Knowledge Level: Understand)
CO 2	Understand neural network architectures and supervised and unsupervised learning algorithms. (Cognitive Knowledge Level: Understand)
CO 3	Apply deep learning and convolutional neural networks to make real world applications. (Cognitive Knowledge Level: Apply)
CO 4	Describe fuzzy logic concepts, fuzzy sets, and fuzzy relations. (Cognitive Knowledge Level: Understand)
CO 5	Design basic fuzzy logic controllers for simple 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	3	1									1
CO 2	3	2	1		2						1
CO 3	3	3	2	2	3	1					2
CO 4	3	1			1						1
CO 5	3	3	3	1	2	1					2

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	20	20	20
Understand	60	60	60
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 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 (7 hours)

Introduction to Neural Networks

Introduction to artificial neural networks, biological foundations of neural systems, basic ANN models, characteristics of artificial neural networks, activation functions.

Basic Neural Models

McCulloch–Pitts neuron model, simple perceptron, learning concepts in neural networks, realization of logic gates, limitations of single-layer models, the XOR problem.

MODULE 2 (8 hours)

Neural Network Architectures and Learning Paradigms

Neural network architectures - single layer, multilayer, and recurrent networks. Knowledge representation in neural networks, learning processes. Overview of supervised, unsupervised and reinforcement learning paradigms

Learning Algorithms

Error-correction learning, backpropagation algorithm - representative case study, Kohonen self-organising maps. Applications of neural networks in classification, pattern recognition, prediction, and signal processing - illustrative examples.

MODULE 3 (7 hours)

Deep Networks

Deep feed-forward neural networks, regularization techniques and optimization methods for training deep models. Challenges in deep learning, dataset augmentation.

Convolutional Networks

Architecture, convolution operation, activation functions, filters and feature maps, pooling, image preprocessing pipeline, batch normalisation. Applications of convolutional neural networks in computer vision.

MODULE 4 (7 hours)

Fuzzy Logic Fundamentals

Introduction to fuzzy logic, the utility of fuzzy systems, limitations, uncertainty and information, crisp sets and fuzzy sets - examples, properties. Basic operations on fuzzy sets. fuzzy relations, cardinality of fuzzy relations, operations on fuzzy relations, properties. Membership functions - triangular, trapezoidal, Gaussian, and sigmoidal functions.

MODULE 5 (7 hours)

Fuzzy Logic Controllers

Structure of fuzzy logic controllers, block diagram. Processes of fuzzification, rule base formation, fuzzy inference mechanism - Mamdani, Sugeno, and Tsukamoto models. Defuzzification methods - max-membership principle, centroid method, weighted average method, mean of maxima, center of sums, center of largest area, and first and last of maxima.

Fuzzy Engineering Application

Introduction to fuzzy decision making, special forms of fuzzy logic models, fuzzy logic controllers for engineering applications - case studies.

Text Books

1. N.Sivanandam, S.N.Deepa, *Principles of Soft Computing*, Wiley India, 2007.
2. Timothy J Ross, *Fuzzy logic with Engineering Applications*, McGraw Hill, New York.
3. George J. Klir/Bo Yuan, *Fuzzy Sets and Fuzzy Logic, Theory and Applications*, Prentice Hall of India, 2005.
4. Tom Mitche, *Machine Learning*, McGraw Hill, 1997.
5. Ian Goodfellow, Yoshua Bengio, Aaron Courville, *Deep Learning*, The MIT Press, 2016.

Reference Books

1. S.Rajasekharan, G.A.Vijayalakshmi Pai, *Neural Network, Fuzzy Logic and Genetic Algorithms Synthesis and Applications*, Prentice Hall India, 2003.
2. Bart Kosko *Neural Network and Fuzzy Systems*, Prentice Hall of India, 2002.
3. Zurada J.M., *Introduction to Artificial Neural Systems*, Jaico Publishers, 2003.
4. Hassoun Mohammed H, *Fundamentals of Artificial Neural Networks*, Prentice Hall of India, 2002.

5. J.-S.R.Jang, C.-T.Sun,E.Mizutani, *Neuro-Fuzzy and Soft Computing*, Springer, 2021.
6. Driankov D., Hellendoorn H., Reinfrank M, *An Introduction to Fuzzy Control*, Narosa Publications, 1993.
7. D.E.Goldberg, *Genetic Algorithms in Search Optimisation and Machine Learning*, Pearson Education, 1989.
8. Francois Chollet, *Deep Learning with Python*, Manning Publications, 2017.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lec- ture/Tuto- rial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Neural Networks & Basic Models	7
1.1	Introduction to artificial neural networks, biological foundations.	1
1.2	Basic ANN models, characteristics of ANNs, activation functions.	1
1.3	McCulloch–Pitts neuron model: Architecture and logic gate realisation.	2
1.4	Simple Perceptron.	1
1.5	Learning concepts, limitations of single-layer models, the XOR problem.	2
	Module 2: Neural Network Architectures and Learning Paradigms	8
2.1	Single layer, multilayer, and recurrent networks; Knowledge representation.	1
2.2	Overview of supervised, unsupervised, and reinforcement learning.	1
2.3	Error-correction learning.	1
2.4	Backpropagation algorithm - theory, derivation.	2
2.5	BPA-case study.	1
2.6	Kohonen self-organising maps (SOM): architecture and training.	1
2.7	Applications of neural networks in classification, pattern recognition, prediction, and signal processing— illustrative examples.	1
	Module 3: Deep Networks and Convolutional Networks	7
3.1	Deep feed-forward neural networks - architecture and challenges.	1
3.2	Regularisation techniques and optimisation methods for deep models.	1
3.3	Dataset augmentation and handling overfitting.	1

3.4	Convolutional Neural Networks (CNN): architecture and convolution operation.	1
3.5	CNN components - filters, feature maps, pooling, and activation functions.	2
3.6	Image preprocessing pipeline and batch normalisation.	1
	Module 4: Fuzzy Set Theory	7
4.1	Introduction to Fuzzy Logic: crisp vs. fuzzy sets, properties.	1
4.2	Basic fuzzy set operations and examples.	1
4.3	Fuzzy relations, composition.	2
4.4	Membership Functions.	3
	Module 5: Fuzzy Logic Controllers and Applications	7
5.1	Structure of Fuzzy Logic Controllers (FLC) - block diagram.	1
5.2	Processes - fuzzification and rule base formation.	1
5.3	Inference Mechanism - Mamdani, Sugeno, and Tsukamoto models.	2
5.4	Defuzzification methods.	2
5.5	Fuzzy engineering applications and case studies.	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Compare the structural and functional aspects of a biological neuron with its artificial counterpart.
2. Explain the significance of the bias term and various activation functions like ReLU and Sigmoid in neural modeling.
3. Realize the 3-input AND gate and OR gate logic using the McCulloch-Pitts neuron model.

Course Outcome 2 (CO 2)

1. Derive the mathematical weight update expression for the Backpropagation algorithm in a multi-layer feed-forward network.
2. Explain the "Winner-Takes-All" learning process in Kohonen Self-Organizing Maps (SOM) with a neat diagram.
3. Distinguish between supervised, unsupervised, and reinforcement learning paradigms with suitable engineering examples.

Course Outcome 3 (CO 3)

1. Describe the architecture of a Convolutional Neural Network (CNN) highlighting the role of convolution, pooling, and fully connected layers.
2. Discuss the common challenges in training deep networks, such as vanishing gradients, and how Batch Normalization helps mitigate them.
3. Explain how data augmentation and dropout techniques are utilized to prevent overfitting in deep learning models.

Course Outcome 4 (CO 4)

1. Define a Fuzzy Set. Differentiate between Crisp and Fuzzy sets using the concept of "Tall men" or "Hot weather" as an example.
2. Explain the properties of fuzzy relations, specifically focusing on Fuzzy Composition (Max-Min and Max-Product).
3. Sketch and mathematically define five different types of membership functions (Triangular, Trapezoidal, Gaussian, Bell-shaped, and Sigmoidal).

Course Outcome 5 (CO 5)

1. Design the rule base for a Mamdani-type Fuzzy Logic Controller for an Air Conditioning system (Inputs: Temperature, Humidity).
2. Given a fuzzy set, calculate the defuzzified output using the Centroid, Weighted Average, and Mean-of-Maxima methods
3. Contrast the Mamdani and Sugeno fuzzy inference models, explaining when each is preferred in control applications.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EE4G24

Course Name: : ARTIFICIAL NEURAL NETWORKS AND FUZZY LOGIC SYSTEMS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. List the essential characteristics of an Artificial Neural Network.
2. Draw the diagram of a McCulloch-Pitts neuron model.
3. What is the significance of the learning rate in the Backpropagation algorithm?
4. Briefly explain the architecture of a Recurrent Neural Network.
5. Define 'Dataset Augmentation' and explain its importance in Deep Learning.
6. Explain the 'Stride' and 'Padding' parameters in a Convolutional layer.
7. Differentiate between the 'Support' and 'Core' of a fuzzy set.
8. Sketch a Trapezoidal membership function and label its parameters.
9. What is the role of the 'Inference Mechanism' in a Fuzzy Logic Controller?
10. Explain the 'Max-Membership' principle of defuzzification.

PART B

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

11. (a) Explain the biological foundations of neural systems and how they translate to artificial models. (7 Marks)
(b) Realize the XOR logic function using a multi-layer perceptron network. (7 Marks)

OR

12. (a) Discuss the Adaline and Madaline architectures and their learning concepts. (7 Marks)
(b) Compare and contrast different types of activation functions like Sigmoid, Tanh, and ReLU. (7 Marks)
13. (a) Describe the architecture and training process of Kohonen Self-Organizing Maps. (7 Marks)
(b) Explain the Hebbian learning rule with a suitable mathematical representation. (7 Marks)

OR

14. Derive the weight update equations for the Backpropagation algorithm for a network with one hidden layer.
15. (a) Explain the challenges associated with training Deep Feed-forward networks. (7 Marks)
(b) Discuss various regularization techniques used to improve deep model generalization. (7 Marks)

OR

16. Describe the complete image preprocessing pipeline and architecture of a Convolutional Neural Network.
17. (a) Explain the properties and basic operations of fuzzy sets. (7 Marks)
(b) Define Fuzzy Relations and explain the concept of Cardinality in fuzzy relations. (7 Marks)

OR

18. (a) Discuss the utility and limitations of fuzzy systems in handling uncertainty. (7 Marks)
(b) Compare Gaussian and Sigmoidal membership functions with their mathematical forms. (7 Marks)
19. (a) Explain the Mamdani and Sugeno fuzzy inference models with neat diagrams. (7 Marks)
(b) Describe the Centroid and Weighted Average methods of defuzzification. (7 Marks)

OR

20. Design a Fuzzy Logic Controller for an engineering application, detailing the fuzzification and rule base formation steps. (14 Marks)

B24EE4G25	ELECTRICAL SYSTEM DESIGN FOR BUILDINGS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The course aims to provide knowledge of electrical symbols, Indian Standard codes, Indian Electricity acts and NEC norms. The course explores the various aspects to design electrical installations with necessary precautions to ensure life safety, risk prevention and continuous operation of the system. By the end of the course, students will be able to design energy-efficient electrical installations in compliance with codes and regulations.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the rules and regulations in the design of medium and high voltage installations. (Cognitive Knowledge Level: Understand)
CO 2	Design lighting schemes for indoor and outdoor applications. (Cognitive Knowledge Level: Apply)
CO 3	Design low/medium voltage domestic and commercial electrical installations. (Cognitive Knowledge Level: Apply)
CO 4	Design industrial electrical installations and 11 kV transformer substation (Cognitive Knowledge Level: Apply)
CO 5	Design electrical installations in high rise buildings and energy conservation. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	2	1	1	2	3	1	2		2
CO 2	3	2	1	3	2	1	1	1	1		2
CO 3	3	3	2	2	2	2	1	1	2	2	2
CO 4	3	3	2	2	2	2	1	1	2	2	2
CO 5	3	3	2	2	2	2	1	1	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	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 (6 hours)

Electrical Installation Standards and Regulations

Electrical Installations - general requirements, design considerations, general awareness of Indian standards, National Electrical Code (SP:30:2023), graphical symbols and signs as per NEC for electrical installations, general awareness of National Building Code, estimation-purpose of estimation and costing. Classification of voltages-standards and specifications, tolerances for voltage and frequency.

MODULE 2 (7 hours)

Illumination Systems and Design

Illumination schemes - types of light sources and lighting arrangements, energy efficiency in lamps and illumination, benefits of LED lamps, Efficacy of present-day LED lamps, design of lighting for interior and exterior applications.

Luminous flux, luminous intensity/illuminance (Lux), illumination calculations, factors affecting Coefficients of Utilisation (CoU), Light Loss Factor (LLF). Design of illumination systems - average lumen method, point to point method.

MODULE 3 (8 hours)

Domestic and Commercial Installations

Design of domestic dwellings - load survey, common power ratings of domestic gadgets, connected load, diversity factor, selection of number of sub circuits (lighting and power). Principle of operation of MCB, MCCB, Isolator, ELCB/RCCB and RCBO. Electrical schematic and physical layout drawings for low and medium class domestic installation, preparation of schedule of works and bill of quantities.

Electrical system design, estimation and costing of commercial buildings - assembly buildings, cinema theatres.

MODULE 4 (8 hours)

Industrial Installations and 11 kV Substations

Industrial installations-classifications, electrical distribution systems of small industries with main switch board, sub switch boards and distribution boards.

11kV indoor and outdoor transformer substations up to 630 kVA, switchgears and protective devices, preparation of schedule of works and bill of quantities, short circuit calculations and earthing design, earth mat, plate and pipe earthing, safety of electrical installations - lightning protection.

MODULE 5 (7 hours)

High-Rise Electrical Installations and Energy Conservation

Electrical installations of high-rise buildings. Distribution systems - rising main, cable system - Installation of lifts, escalators, standby generators.

Energy Conservation Techniques in electrical power distribution - Energy Economics in system design.

AutoCAD - introduction, commands, applications.

Text Books

1. M. K. Giridharan, *Electrical Systems Design*, I K International Publishers, 2nd ed., 2020.
2. J. B. Gupta, *A Course in Electrical Installation Estimating and Costing*, S.K. Kataria & Sons; Reprint 9th ed., 2018.
3. K. B. Raina, S. K. Bhattacharya, *Electrical Design Estimating and Costing*, New Age International Publishers, 3rd ed., 2024.

Reference Books

1. V K Jain, *Design of Electrical Installations*, Laxmi Publications, 2nd ed., 2016.
2. S K Battacharya, *Electrical Engineering Drawing*, New Age International Publishers, 3rd ed., 2022.
3. N Rajendran, *Design of Electrical systems*, 1st ed., 2014.
4. S L Uppal, *Electrical wiring, estimating and costing*, Khanna Publishers, 6th ed., 2025.
5. National Electrical Code SP 30:2023.
6. National Building Code, 2016.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Electrical Installation Standards and Regulations	6

1.1	Electrical Installations - general requirements, design considerations, general awareness of Indian standards	2
1.2	National Electrical Code (SP:30:2023), graphical symbols and signs as per NEC for electrical installations	2
1.3	General awareness of National Building Code, estimation-purpose of estimation and costing. Classification of voltages-standards and specifications, tolerances for voltage and frequency	2
	Module 2: Illumination Systems and Design	7
2.1	Illumination schemes - types of light sources and lighting arrangements	1
2.2	Energy efficiency in lamps and illumination, benefits of LED lamps, Efficacy of present-day LED lamps, design of lighting for interior and exterior applications	2
2.3	Luminous flux, luminous intensity/illuminance (Lux), illumination calculations, factors affecting Coefficients of Utilisation (CoU), Light Loss Factor (LLF)	2
2.4	Design of illumination systems - average lumen method, point to point method	2
	Module 3: Domestic and Commercial Installations	8
3.1	Design of domestic dwellings - load survey, common power ratings of domestic gadgets, connected load, diversity factor, selection of number of sub circuits (lighting and power)	2
3.2	Principle of operation of MCB, MCCB, Isolator, ELCB/RCCB and RCBO	2
3.3	Electrical schematic and physical layout drawings for low and medium class domestic installation, preparation of schedule of works and bill of quantities	2
3.4	Electrical system design, estimation and costing of commercial buildings - assembly buildings, cinema theatres	2
	Module 4: Industrial Installations and 11 kV Sub-stations	8
4.1	Classifications, electrical distribution systems of small industries with main switch board, sub switch boards and distribution boards	2
4.2	11kV indoor and outdoor transformer substations up to 630 kVA, switchgears and protective devices	2
4.3	Preparation of schedule of works and bill of quantities, short circuit calculations and earthing design	2
4.4	Earth mat, plate and pipe earthing, safety of electrical installations - lightning protection	2
	Module 5: High-Rise Electrical Installations and Energy Conservation	7
5.1	Electrical installations of high-rise buildings: Distribution systems - rising main, cable system	2
5.2	Installation of lifts, escalators, standby generators	2

5.3	Energy Conservation Techniques in electrical power distribution - Energy Economics in system design	1
5.4	AutoCAD - introduction, commands, applications	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain National building code.
2. Significance of CEA.
3. Illustrate symbols and signs as per NEC.

Course Outcome 2 (CO 2)

1. Problems on lighting design.
2. Explain luminous flux and illuminance.
3. Design of public area lighting .

Course Outcome 3 (CO 3)

1. Explain working of RCCB.
2. Illustrate electrical aspects of lifts.
3. Design of domestic installation.

Course Outcome 4 (CO 4)

1. Explain the selection of bus bars and switch gears.
2. Design and estimation for industrial installations.
3. Design of 11 kV substation. .

Course Outcome 5 (CO 5)

1. Explain the energy conservation techniques in electrical power distribution.
2. Illustrate the rising main system.
3. Design electrical installations for high rise buildings.

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EE4G25

Course Name: : ELECTRICAL SYSTEM DESIGN FOR BUILDINGS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Discuss the relevance of IS codes.
2. Draw the standard symbols for circuit breaker, auto transformer starter and overhead line.
3. Explain Efficacy and CoU.
4. Enumerate the factors affecting LLF.
5. Differentiate between MCB and MCCB.
6. Explain the role of load survey.
7. Select a cable size, starting device, SFU and fuse rating for a 3-phase, 415V, 50 Hz, 15 Hp Squirrel cage induction motor.
8. Draw single line diagram of a 11 kV/415 V outdoor substation with rating of components.
9. What are the rising main systems utilized in high-rise buildings? Draw a neat diagram.
10. Enumerate the factors to be considered while installing standby generators.

PART B

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

11. Explain the salient features of NEC SP 30:2023. (14 marks)

OR

12. Explain the relevance and features of National Building Code . (14 marks)

13. (a) Explain the construction and working principle of LED lamps. (6 marks)

- (b) An assembly shop of 20 m long, 10 m wide and 4 m upto the truss is to be illuminated at a level of 220lux. Take Coefficient of Utilisation = 0.75 and maintenance factor = 0.8. Calculate the number of lamps required for the illumination system. Lumen output of lamp = 3500 lumens. Assume any other required data appropriately. (8 marks)

OR

14. (a) Explain the general considerations for a good interior lighting scheme.(6 marks)

- (b) A certain incandescent lamp, hangs from the ceiling of a room. The illuminance received on a small horizontal screen lying on a bench 2m vertically below the lamp is 63.5 lux. Calculate illuminance at a point when the screen is moved horizontally a distance of 1.5m along the bench. (8 marks)

15. A guest-house has six air-conditioned rooms with private bathrooms, a kitchen, and a dining room. Prepare a room-by-room list of electrical installation materials. Draw a schematic of the distribution board with MCB ratings and sub-circuits indicated. The design must conform to NEC specifications. Assume any other required data appropriately. (14 marks)

OR

16. (a) Explain the electrical design of a cinema theatre. (8 marks)

- (b) Determine the total connected load, type of supply, and number of sub circuits for a home with the following rooms: one bedroom with an attached bathroom, living room, dining room, and kitchen. Determine the number of light, fan, socket, and exhaust fan points required by NEC for the structure. Assume any other required data appropriately. (6 marks)

17. (a) Draw the single line diagram of a motor circuit wiring. What are the design criteria to be followed while selecting cable and circuit breaker for a motor circuit wiring? (5 marks)

- (b) For a 11kV HT consumer, design the earthing system and calculate the number of plate earth pits (size of plate: 1200mm x1200mm x12mm).Soil resistivity =100 Ω -m,current density for copper = 118A/mm²,11kV side fault current =8.704 kA. Assume any other required data appropriately. (9 marks)

OR

18. (a) A small workshop 30m x 20 m has to be equipped with the following machinery: (i) 5hp, 415V, 3phase induction motor (ii) 3hp, 415V, 3phase induction motor (iii) 0.5hp, 230V, 1 phase motor. Estimate the quantity of materials required for the installation. (6 marks)
- (b) In a village, residential load of 20 kW, agriculture load of 30 hp, and water pump of 10 hp has to be electrified. Make a list of materials for installing an outdoor substation with a single line diagram. (8 marks)
19. (a) Discuss the energy conservation techniques in electrical installations. (6 marks)
- (b) Explain the installation of lifts. (8 marks)

OR

20. A six storeyed building has 24 flats. The load in each flat is 10 kW. Design the electrification for this building and draw the schematic layout of this building. Assume the other loads in the building. (14 marks)

B24EE4G26	SPECIAL MACHINES	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course provides a comprehensive understanding of the construction, principle of operation, characteristics, and control methods of special electrical machines. By the end of the course, students will be able to select appropriate special electrical machines, analyze the performance and implement control strategies when used in industrial and automation applications..

Prerequisites

Electrical Machines I, Electrical Machines II

Course Outcomes

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

CO 1	Understand the construction and principle of operation of the servomotor and analyze its performance characteristics. (Cognitive Knowledge Level: Apply)
CO 2	Understand the basic principle and construction of stepper motor, analyze its performance characteristics and compare the different types of stepper motor. (Cognitive Knowledge Level: Apply)
CO 3	Understand the construction, operating principles, torque equation, control methods, characteristics, and applications of synchronous and switched reluctance motors. (Cognitive Knowledge Level: Apply)
CO 4	Analyze the performance characteristics and control methods of different types of permanent magnet motors. (Cognitive Knowledge Level: Apply)
CO 5	Understand the construction, principles of operation, and applications of single-phase special electrical machines and linear electric machines, and analyze their basic performance characteristics. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2				1	1				1
CO 2	3	2				1	1				1
CO 3	3	2				1	1				1
CO 4	3	2				1	1				1
CO 5	3	2				1	1				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/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 (7 hours)

Servo Motors

DC servo motors - construction, principle of operation, transfer function of field and armature controlled DC servo motors, permanent magnet armature controlled DC servo motor, series split field DC servo motor - applications.

AC servo motors - construction, principle of operation, performance characteristics, damped AC servo motors, drag cup servo motors, applications

MODULE 2 (7 hours)

Stepper Motors

Stepper motors - basic principles, different types - variable reluctance, permanent magnet, hybrid type - principle of operation, comparison, monofilar and bifilar windings, modes of excitation, static and dynamic characteristics, open loop and closed loop control of stepper motor, applications

MODULE 3 (7 hours)

Reluctance Motors

Synchronous reluctance motor - construction, principle of operation, phasor diagram - torque equation, applications.

Switched reluctance motors(SRM) - principle of operation, torque equation, characteristics, power converter circuits, control of SRM, rotor position sensors, torque pulsations, sources of noise, noise mitigation techniques, applications.

MODULE 4 (7 hours)

Permanent Magnet(PM) Motors

Permanent Magnet DC Motors – construction, principle of operation..

PM Brushless DC motor(BLDC) - construction, principle of operation, permanent magnets - different types, demagnetization characteristics, arrangement of permanent magnets, magnetization of permanent magnets - axial and parallel magnetizations, control of BLDC motor, applications.

PM synchronous motors - construction, principle of operation, control of PMSM, self control, sensor less control, applications, comparison with BLDC motors.

MODULE 5 (8 hours)

Single Phase Special Electrical Machines

AC series motor, repulsion motor, hysteresis motor, universal Motor - construction, principle of operation, applications.

Linear motors - types, linear reluctance motor, linear synchronous motors, construction, comparison, linear Induction motor - construction, thrust equation, transverse edge and end effects, equivalent circuit, thrust-speed characteristics, applications.

Text Books

1. E.G.Janardhanan,*Special Electrical Machines*, PHI Learning Private Limited, 2014.
2. K. Venkataratnam, *Special Electrical Machines*, Universities Press, 2021.

Reference Books

1. R. Krishnan, *Permanent magnet synchronous and Brushless DC motor Drives*,CRC Press, 1st ed., 2009.
2. T. J. E. Miller, *Brushless PM and Reluctance Motor Drives*, C. Larendon Press, Oxford.
3. Theodore Wildi,*Electric Machines, Drives and Power Systems*, Prentice Hall India. Ltd.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Servo Motors	7
1.1	DC servo motors - construction, principle of operation	1
1.2	Transfer function of field and armature controlled DC servo motors,	1
1.3	Permanent magnet armature controlled DC servo motor,	1
1.4	Series split field DC servo motor- applications	1
1.5	AC servo motors - construction, principle of operation .	1
1.6	AC characteristics, damped AC servo motors	1
1.7	Drag cup servo motors, applications	1
	Module 2:Stepper Motors	7
2.1	Stepper motors - basic principles, different types	1

2.2	Variable reluctance motors, principle of operation, modes of excitation	1
2.3	Permanent magnet motors, principle of operation	1
2.4	Hybrid motors, principle of operation	1
2.5	Comparison, monofilar and bifilar windings	1
2.6	Static and dynamic characteristics	1
2.7	Open loop and closed loop control of stepper motor, applications	1
	Module 3:Reluctance Motor	7
3.1	Synchronous reluctance motor, construction, principle of operation	1
3.2	Phasor diagram, torque equation, applications	1
3.3	Switched reluctance motors (SRM) - principle of operation	1
3.4	Torque equation, characteristics	1
3.5	Power converter circuits, control	1
3.6	Rotor position sensors, torque pulsations	1
3.7	Sources of noise, noise mitigation techniques, applications.	1
	Module 4: Permanent Magnet(PM) Motors	7
4.1	Permanent Magnet DC Motors-construction, principle of operation	1
4.2	PM Brushless DC motor (BLDC) - construction, principle of operation	1
4.3	different types, demagnetization characteristics, arrangement of permanent magnets,	1
4.4	Magnetization of permanent magnets - axial and parallel magnetizations	1
4.5	Permanent Magnet Synchronous Motors (PMSM) - construction, principle of operation	1
4.6	control - vector Control, sensor less control	1
4.7	Applications, comparison with BLDC motors.	1
	Module 5:Single Phase Special Electrical Machines	8
5.1	AC series motor- construction, principle of operation, applications	1
5.2	Repulsion motor- construction, principle of operation, applications	1
5.3	Hysteresis motor - construction, principle of operation, applications	1
5.4	Linear motors, different types - linear reluctance motor	1
5.5	Linear synchronous motors - construction, comparison	1
5.6	Linear induction motor - construction, thrust equation,	1
5.7	Transverse edge and end effects equivalent circuit, thrust-speed characteristics, applications	1
5.8	Thrust-speed characteristics, applications	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the constructional details of any servo motor.
2. Discuss the role of servo motors in automation systems.
3. Explain the constructional details and working principle of drag cup motor

Course Outcome 2 (CO 2)

1. Explain the working of any type of stepper motor with a neat diagram.
2. Explain the different configurations for switching the phases of a stepper motor..
3. Numerical problems from stepper motors.

Course Outcome 3 (CO 3)

1. Derive the torque equation of any motor.
2. Draw the phasor diagram of a synchronous reluctance motor.
3. Explain any two power converter circuits used for the control of SRM.

Course Outcome 4 (CO 4)

1. Explain the principle of operation of any motor.[
2. List the permanent magnets used in motors and explain their magnetization characteristics.
3. Problems based on emf and torque of PMBLDC motor and PMSM

Course Outcome 5 (CO 5)

1. Explain the principle of operation of a LIM.
2. What are the different types of Linear motors?
3. Derive the thrust equation of a LIM.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EE4G26

Course Name: : SPECIAL MACHINES

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What are the applications of servo motors? .
2. Draw and explain the performance characteristics of an AC servo motor.
3. Define the following terms as applied to stepper motors (i) Holding Torque (ii) Step accuracy (iii) Detent position.
4. What is meant by micro stepping in stepper motors? What are its advantages?
5. Draw the torque -slip characteristics of a Reluctance motor.
6. Explain the drawbacks of a Switched Reluctance motor.
7. Explain the constructional details of PMBLDC Motor. .
8. Explain the sensor less control of PMSM.
9. Explain the working principle of a hysteresis motor.
10. Derive the expression for linear force in LIM

PART B

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

11. With the help of a schematic diagram, explain the working of the field controlled d.c servomotor with its transfer function model. (14 marks)

OR

12. Explain the constructional features and working principle of AC Servomotors and compare it with the characteristics of DC servomotor. (14 marks)
13. (a) With neat sketches, explain the constructional details and working principle of the variable reluctance stepper motor. (10 marks)
- (b) List any four applications of stepper motors (4 marks)

OR

14. (a) A permanent magnet stepper motor is driven by a series of pulses of duration 20ms. It has 4 stator poles and 6 rotor poles. How long will it take for the motor to make a complete rotation? (8 marks)
- (b) Compare variable reluctance, permanent magnet and hybrid stepper motors. (6 marks)
15. (a) With neat sketches explain the construction and operation of 8/6 SRM. (8 marks)
- (b) Draw and explain $n+1$ switches and diode configuration power converter for the SRM. (6 marks)

OR

16. (a) Derive the torque equation of a synchronous reluctance motor. (8 marks)
- (b) Explain the basic principle of operation of a synchronous reluctance motor. (6marks)
17. (a) Explain the principle of operation of the PMSM motor with a neat circuit diagram showing the complete drive circuit. (8 marks)
- (b) Differentiate trapezoidal and sinusoidal back emf permanent magnet motors. (6 marks)

OR

18. (a) Explain the constructional details and working principle of the permanent magnet dc motor. (8 marks)
- (b) Explain the demagnetisation characteristics and choice of permanent magnets in a Brushless DC motor. (6 marks)
19. (a) Why is compensating winding used in AC series motors? Draw a series motor with different types of compensating windings. (8 marks)
- (b) What are the modifications to be made in the DC series motor to operate it in an AC supply? (6 marks)

OR

20. (a) Develop the equivalent circuit of a LIM and describe the main factors affecting its performance (8 marks)
- (b) Explain the end effect and transverse edge effect in LIM. (6 marks)

B24EE4L12	PROJECT PHASE I	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	6	2	3	2024

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 the 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:

CO 1	Apply engineering knowledge across domains to model, analyze, and solve real-world problems through practical design, simulation, or prototyping. (Cognitive Knowledge Level: Apply)
CO 2	Develop innovative, sustainable, and socially relevant products, processes, or systems, addressing technology/research gaps while considering ethical, environmental, and SDG-aligned aspects. (Cognitive Knowledge Level: Apply/Create)
CO 3	Function effectively as an individual and as a leader/member in diverse teams, demonstrating responsibility, collaboration, and task execution in multidisciplinary settings. (Cognitive Knowledge Level: Apply)
CO 4	Plan, schedule, and execute project tasks efficiently using available resources within timelines while adhering to ethical, professional, and budgetary norms. (Cognitive Knowledge Level: Apply)
CO 5	Identify gaps through literature review and propose creative solutions; organize and communicate technical findings effectively in written reports and oral presentations. (Cognitive Knowledge Level: Analyze/Apply)

Mapping of Course Outcomes with Program Outcomes

(Correlation levels: 3 = High, 2 = Medium, 1 = Low, blank = None)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	2	2	1		1			1
CO2	2	2	3	1	1	2	3	2	1	1	2
CO3					3	2	3	2	2	1	
CO4	1	1	1		2	1	1	2	3	3	3
CO5	2	3	2	2	2	1	1	1	2	3	2

SDG Relevance- Projects should align with United Nations Sustainable Development Goals (SDGs), such as SDG 9 (Industry, Innovation, and Infrastructure), SDG 7/13 (Clean Energy and Climate Action), SDG 11 (Sustainable Cities and Communities), and SDG 3/6 (Health and Clean Water), particularly in CO2 and problem definition.

Phase 1 Targets (with emphasis on sustainability and 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)

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)

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)

No.	Parameters	Marks	Poor	Fair	Very Good	Outstanding
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 and 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)

No.	Parameter	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 the same batch unless it is an interdisciplinary project.
- For the project, identify one base paper publication. It should be from IEEE, Elsevier, ACM journals, Science Citation Index (SCI) journals, or reputed Scopus-indexed journals. Conference papers are not permitted. Only recently published papers are allowed.
- For the literature survey, at least 10 publications are to be reviewed.
- Students are encouraged to seek funding from agencies such as KSCSTE, CERD, etc. Projects with societal relevance have a higher probability of attracting funding and recognition.
- Every student must maintain an individual project diary in the prescribed format. All project-related activities must be recorded with dates. The diary should be reviewed

weekly by the project guide and signed (or approved via email in case of online mode). Project diaries may be collected periodically for evaluation.

- At the end of the seventh semester, a project report must be prepared in the prescribed format.
- Students should proceed with the project work with the objective of publishing at least one research paper during the eighth semester.



B24EE4L13	SEMINAR	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	4	1	2	2024

Preamble

The course '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:

1. To conduct a literature survey in a selected engineering area of interest.
2. To understand and analyze academic/technical documents from peer-reviewed sources.
3. To prepare and deliver an effective presentation on the selected document/topic.
4. To prepare a comprehensive technical report with accurate references and consideration for sustainability and ethics where relevant.

Course Outcomes

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

CO 1	Identify and select relevant academic documents from literature in their area of interest. (Cognitive Knowledge Level: Apply)
CO 2	Read, comprehend, and analyze an academic document/technical paper related to their area of interest. (Cognitive Knowledge Level: Analyze)
CO 3	Prepare a structured presentation on the selected academic document. (Cognitive Knowledge Level: Create)
CO 4	Deliver an effective presentation and engage in discussions/Q&A on the academic document. (Cognitive Knowledge Level: Apply)
CO 5	Prepare a well-structured technical report with proper references, formatting, and consideration for societal/sustainable aspects where applicable. (Cognitive Knowledge Level: Create)

Mapping of Course Outcomes with Program Outcomes (NBA 11 POs, GAPC V4.0)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	2	1	1	–	2	1	–	–	–	3
CO2	3	3	2	3	–	2	1	–	–	–	3
CO3	3	2	2	–	3	–	–	1	–	2	3
CO4	3	–	–	–	2	–	–	1	–	3	3
CO5	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 must be present during presentations.
- IEC formation and guide allotment shall be completed within one week after previous semester examinations/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 and submit to IEC in Week 1; IEC approval to be completed by Week 2.
- Accurate references from genuine peer-reviewed sources are required (to be verified in the report).
- Maintain a seminar diary for weekly progress monitoring by the 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 seminar diary entries.
- **Relevance of Topic/Paper Selected (10 marks):** Evaluated based on alignment with the discipline, currency, breadth, linkage to final-year project/SDGs (if applicable), and justification.

Rubric for Background Knowledge (10 marks)

Guide awards marks holistically or as an average of 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):** Assessed based on weekly progress entries, guide approvals, and 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.

Level	Score	Descriptor
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) – 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 over run/under run.
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 the 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.

Criterion	Weight	Excellent (4) – Full marks scaled	Good (3)	Satisfactory (2)	Unsatisfactory (1)
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) – Full 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.

Criterion	Weight	Excellent (4) – Full scaled	Good (3)	Satisfactory (2)	Unsatisfactory (1)
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.

B24EE4T02	VIVA-VOCE	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	0	-	1	2024

Evaluation Scheme: Comprehensive Viva (CIE Only)

- **Evaluation Mode:** 100% Continuous Internal Evaluation (CIE) – No End Semester Examination (ESE).
Minimum pass: 50 marks out of 100.
- **Objective:** 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:
 - Fundamental concepts and theories
 - Problem-solving and numerical analysis
 - Derivations and logical reasoning
 - Practical applications and case-based questions
 - Interconnections between subjects
- **Conduct:** Viva voce conducted by a panel consisting of an internal examiner and the HoD/senior faculty.
 - Duration: 15–30 minutes per student (individual)
 - May include follow-up questions
 - Blackboard explanations/derivations may be required

Evaluation Scheme & Rubrics (Total: 100 Marks)

The evaluation is holistic and panel-based. Marks are awarded individually based on performance during the viva.

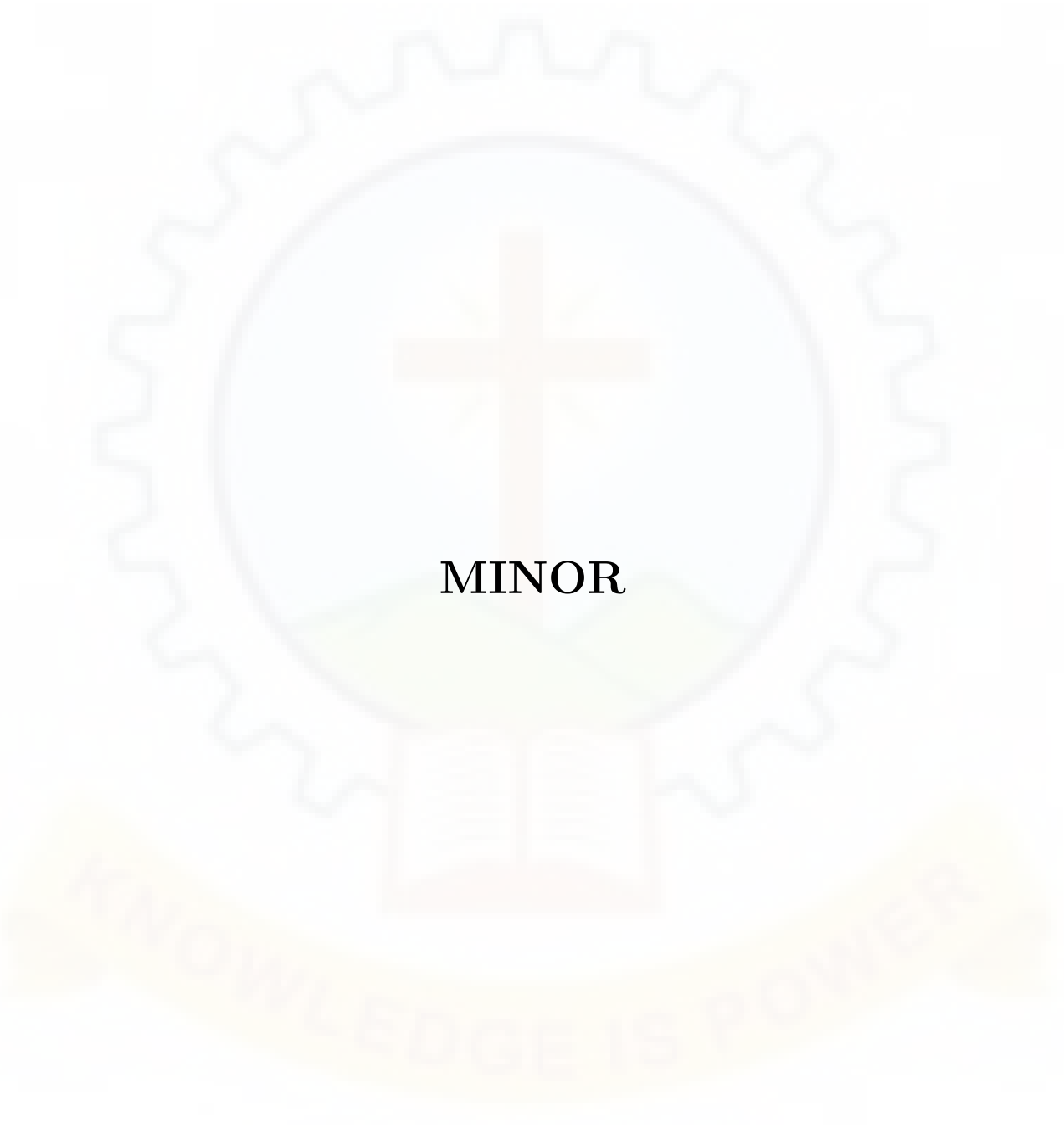
Parameter	Marks	Poor (0–10)	Fair (11–20)	Good (21–30)	Very Good (31–40)	Excellent/ Outstanding (41–50)
Depth of Subject Knowledge (Core concepts, definitions, laws, theorems, derivations from all major core subjects up to S6)	50	Very limited recall; major gaps in fundamentals; unable to answer basic 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.
Understanding & Application (Ability to apply concepts, solve simple problems, explain real-world relevance, inter-connections)	20	No meaningful application; rote answers only; cannot relate concepts or solve basic problems.	Limited application; struggles with simple problems or real-world links.	Fair application; solves basic problems; some understanding of relevance.	Good application; solves medium-level problems; explains practical/industrial relevance.	Outstanding application; solves unseen problems creatively; clearly links concepts across domains and to societal/engineering contexts.
Clarity of Expression & Communication (Verbal clarity, logical flow, use of technical terms, confidence in answering)	15	Poor articulation; unclear/hesitant; frequent incomplete answers or mumbling.	Somewhat clear but disorganized; needs repetition/prompting often.	Clear and logical most of the time; minor hesitations.	Fluent, well-structured answers; confident delivery; uses precise terminology.	Highly articulate, confident, and professional; excellent logical flow; engages panel effectively.

Parameter	Marks	Poor (0–10)	Fair (11–20)	Good (21–30)	Very Good (31–40)	Excellent/ Outstanding (41–50)
Overall Confidence, Attitude & Responsiveness (Body language, honesty in admitting unknowns, eagerness to learn/explain further)	15	Nervous/unresponsive; defensive or silent on difficult questions.	Somewhat confident but anxious; partial responses.	Generally confident; admits gaps reasonably.	Confident and composed; handles pressure well.	Highly confident, positive attitude; turns unknown questions into discussion points; demonstrates lifelong learning mindset.

Total: 100 Marks

Guidelines for Preparation & Conduct

- Students should revise all core theory and laboratory courses from Semesters 1 to 6.
- Focus on both fundamental concepts and advanced topics.
- The viva is typically scheduled in the last 1–2 weeks of the 7th semester.
- There is no written component; the evaluation is purely oral, but may include diagrams or derivations on the board.



MINOR

B24EEM71	ROBOTICS AND AUTOMATION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course aims to develop a solid conceptual and analytical foundation by combining theoretical principles with practical applications in modern robotic systems. It focuses on fundamentals of robotics and automation, covering robot anatomy, sensors, actuators, kinematics, dynamics and robot control. This course will help students to analyze, design, and apply robotic solutions effectively in diverse industrial automation and robotics-related careers.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the fundamentals of robotics including robot anatomy, characteristics, degrees of freedom, types and sensing systems. (Cognitive Knowledge Level: Understand)
CO 2	Classify and select different actuators used for robotic applications and describe various robot configurations. (Cognitive Knowledge Level: Understand)
CO 3	Analyze robot kinematics and trajectory planning techniques. (Cognitive Knowledge Level: Apply)
CO 4	Develop dynamic models of robotic systems and its control strategies. (Cognitive Knowledge Level: Apply)
CO 5	Understand industrial automation principles and identify suitable solutions for industrial applications. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	40	20	20
Understand	60	40	40
Apply		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 (10 hours)

Introduction to Robotics

Definition and origin of robotics, types of robots - manipulators, mobile robots - wheeled & legged robots, aerial robots, robot anatomy - types of joints and end effectors, robot characteristics - accuracy, precision and repeatability, degrees of freedom.

Robotic sensors - touch, position, velocity, force, proximity, range and vision sensors, internal sensors and external sensors, robotic vision systems.

MODULE 2 (7 hours)

Actuators for Robots

Selection parameters, electric actuators - stepper motors, dc motors, dc servo motors and their drivers, ac motors, linear actuators, selection of motors, components and typical circuit of hydraulic actuators and pneumatic actuators, advantages and disadvantages.

Robot Configurations

Prismatic Prismatic Prismatic (PPP), Revolute Prismatic Prismatic (RPP), Revolute Revolute Prismatic (RRP), Revolute Revolute Revolute (RRR), features of SCARA, PUMA Robots.

MODULE 3 (9 hours)

Robot Kinematics

Direct kinematics, translations and rotations - fundamental and composite rotations, rigid motion representation using homogenous transformation matrix, coordinate transformations, forward and inverse kinematics - roll, yaw and pitch angles, Euler angles, DH representation, arm equation.

Trajectory Planning

Basics of trajectory planning, joint space technique - use of p-degree polynomial, cubic polynomial, cartesian space technique, position and orientation planning.

MODULE 4 (12 hours)

Dynamics of Robots

Inertia properties, kinetic and potential energy expression, Euler - Lagrange's equation, dynamic modelling of 1 DOF and 2 DOF robot.

Introduction to Robot Control

Control techniques, transfer function and state space representation, performance and stability of feedback control, PID control of a single link manipulator, PD gravity control, selection of PID controller gains, nonlinear nature of manipulators, need for nonlinear control techniques, computed torque control.

MODULE 5 (7 hours)

Industrial Automation and Applications

General aspects, elements, applications, advantages and limitations of automation, types of automation, assembly automation equipment.

Welding, spray painting, grinding, material handling and transfer, machine loading and unloading, assembly operations, sorting of parts, case study - robotic configuration for pick and place robot.

Text Books

1. S.K. Saha, *Introduction to Robotics*, Tata McGraw Hill, 2nd ed., 2014
2. Saeed B. Niku, *Introduction to Robotics: Analysis, Control, Applications*, Wiley India Pvt Ltd, 2024.
3. R.K.Rajput, *Robotics and industrial automation*, S.Chand Limited, 2008
4. Mikell P. Groover, et al., *Industrial Robotics – Technology, Programming and Applications*, McGraw Hill, 2nd ed., 2012
5. R K Mittal and I J Nagrath, *Robotics and Control*, Tata McGraw Hill, New Delhi, 2003

Reference Books

1. John. J.Craig, *Introduction to Robotics: Mechanics and Control*, PHI, 2005.
2. Robert J. Schilling, *Fundamentals of Robotics: Analysis & Control*, Pearson Education, 2000
3. Klafter, R.D, Chmielewski, T.A, Negin, M, *Robotic Engineering An Integrated Approach*, PHI, 2007

4. Ashitava Ghosal, *Robotics, Fundamental concepts and analysis*, Oxford University Press, 2006
5. S. R. Deb, *Robotics Technology and Flexible Automation*, Tata McGraw Hill, New Delhi, 1994.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lec- ture/Tuto- rial Hours
	Total Hours	45 Hours
	Module 1:Introduction to Robotics	10
1.1	Definition and origin of robotics, types of robots - manipulators	1
1.2	mobile robots - wheeled legged robots, aerial robots,	1
1.3	robot anatomy - types of joints	1
1.4	end effectors	2
1.5	robot characteristics - accuracy, precision and repeatability, degrees of freedom	1
1.6	Robotic sensors - touch, position, velocity	1
1.7	force, proximity, range and vision sensors	1
1.8	internal sensors and external sensors	1
1.9	robotic vision systems	1
	Module 2: Actuators for Robots, Robot Configurations	7
2.1	Selection parameters, electric actuators - stepper motors	1
2.2	dc motors, dc servo motors and their drivers	1
2.3	ac motors, linear actuators, selection of motors	1
2.4	components and typical circuit of hydraulic actuators	1
2.5	pneumatic actuators, advantages and disadvantages	1
2.6	Prismatic PrismaticPrismatic (PPP), Revolute Prismatic Prismatic (RPP), Revolute Revolute Prismatic (RRP), Revolute RevoluteRevolute (RRR),	1
2.7	features of SCARA, PUMA Robots	1
	Module 3:Robot Kinematics, Trajectory Planning	9
3.1	Direct kinematics, translations and rotations - fundamental and composite rotations	1
3.2	rigid motion representation using homogenous transformation matrix,	1
3.3	coordinate transformations	1
3.4	forward and inverse kinematics - roll, yaw and pitch angles	1
3.5	Euler angles, DH representation, arm equation	1
3.6	Basics of trajectory planning, joint space technique.	1
3.7	use of p-degree polynomial, cubic polynomial	1
3.8	cartesian space technique, position and orientation planning	2

	Module 4:Dynamics of Robots, Introduction to Robot Control	12
4.1	Inertia properties, kinetic and potential energy expression	1
4.2	Euler - Lagrange's equation	1
4.3	dynamic modelling of 1 DOF robot	1
4.4	Control techniques, transfer function and state space representation	2
4.5	performance and stability of feedback control,	1
4.6	PID control of a single link manipulator	1
4.7	PD gravity control, selection of PID controller gains	1
4.8	nonlinear nature of manipulators	1
4.9	need for nonlinear control techniques,	2
4.10	computed torque control	1
	Module 5:Industrial Automation and Applications	7
5.1	General aspects, elements, applications, advantages and limitations of automation	1
5.2	types of automation	1
5.3	assembly automation equipment	2
5.4	Welding, spray painting, grinding, material handling and transfer	1
5.5	machine loading and unloading, assembly operations, sorting of parts	1
5.6	case study - robotic configuration for pick and place robot	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Position sensors are not preferred to obtain the velocity and acceleration. Give reason.
2. Describe the various joint configurations in a robotic manipulator.
3. Explain robotic vision system.

Course Outcome 2 (CO 2)

1. Draw the block diagram of a hydraulic actuator. Detail the components.
2. Explain the RRR robot configuration with a suitable diagram.
3. Draw a functional diagram of a PUMA robot in detail. List the parts.

Course Outcome 3 (CO 3)

1. Explain the arm equation of a robotic manipulator.
2. Compare joint space trajectory planning and Cartesian trajectory planning.
3. A frame is rotated 30 degree about X-axis and then 60 degree about Y-axis. Determine the composite rotation matrix.

Course Outcome 4 (CO 4)

1. Draw the block diagram of a PID controller and explain the components.
2. Explain the need for nonlinear control in robot manipulators.
3. A control system has a constant error signal $e(t) = 5e(t)$. The controller gains are $K_p = 2$, $K_i = 1$ and $K_d = 0.5$. Using the PID control law, determine the control output $u(t)$.

Course Outcome 5 (CO 5)

1. Define industrial automation.
2. Explain the working of assembly automation equipment such as feeders and conveyors.
3. Describe machine loading and unloading operation using robots.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EEM71

Course Name: : ROBOTICS AND AUTOMATION

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define Precision, Accuracy, and Repeatability of a robot.
2. Explain external sensors with two examples.
3. Draw a neat diagram of PPP robot configuration.
4. Which type of actuator would be most suitable for unloading 1000 kg items from a die casting machine. Explain the reasoning behind your choice.
5. Define roll, yaw and pitch angle in robot orientation.
6. Differentiate between forward and inverse kinematics.
7. Compare transfer function and state space representation of a system.
8. State Euler–Lagrange equation.
9. State advantages and limitations of automation.
10. List common assembly automation equipment.

PART B

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

11. (a) Describe the general features of wheeled, legged and aerial robots. (8 marks)
(b) With the help of a diagram, explain the anatomy of a robotic manipulator. (6 marks)

OR

12. (a) Draw and explain position and velocity internal sensors. (8 marks)
(b) Describe the various sensor characteristics to be considered in the choice of the sensor for robotic application. (6 marks)
13. Explain different types of actuators used in robots and discuss their advantages and disadvantages. (14 marks)

OR

14. (a) Explain SCARA robot configuration with the help of a diagram. (7 marks)
(b) List the differences between RRP configuration and a SCARA robot. (7 marks)
15. (a) Describe the rigid body motion representation using homogeneous transformation matrix. (7 marks)
(b) Explain the Denavit–Hartenberg (DH) representation with parameters used in robot kinematics. (7 marks)

OR

16. (a) Explain the steps involved in robot trajectory planning (7 marks)
(b) Derive the general equation of a p-degree polynomial trajectory and explain its use. (7 marks)
17. (a) Explain computed torque control in a robotic manipulator with the help of a diagram. (10 marks)
(b) Can PID control be used for nonlinear system? Explain the reasoning. (4 marks)

OR

18. Derive the dynamics for a 1 degree of freedom (DOF) robotic manipulator having a revolute joint. (14 marks)
19. (a) Explain the applications of robot in the following areas a) Welding b) Spray Painting. (7 marks)
(b) Describe the working principle of automated sorting systems. (7 marks)

OR

20. Classify various types of industrial automation and illustrate each with examples. (14 marks)

B24EEM72	HVDC TRANSMISSION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

The course introduces the fundamentals of High Voltage Direct Current (HVDC) transmission systems with emphasis on basic principles, system components, and operational concepts. The course focuses on conceptual understanding, making it suitable for students from engineering disciplines other than Electrical Engineering. By the end of the course, students will gain awareness of modern power transmission technologies and the role of HVDC in large-scale power transfer and renewable energy integration.

Prerequisites

Solid State Power Conversion

Course Outcomes

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

CO 1	Understand the need for HVDC transmission and explain its basic principles, configurations, advantages, and comparison with AC transmission systems. (Cognitive Knowledge Level: Understand)
CO 2	Explain the operating principles, configurations, and performance characteristics of HVDC converters. (Cognitive Knowledge Level: Understand)
CO 3	Analyze HVDC control strategies including DC link control, converter control, and higher-level controllers for stable and reliable power transmission. (Cognitive Knowledge Level: Apply)
CO 4	Understand the importance of protection in HVDC systems and explain common fault types, protection concepts. (Cognitive Knowledge Level: Understand)
CO 5	Explain the components and harmonic behavior of HVDC systems and analyze their role in renewable energy integration. (Cognitive Knowledge Level: Apply)

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	1	1		3	1
CO 2	3	3	3	2		2	1	1			1
CO 3	3	3	3	2		2	1	1			1
CO 4	3	2	3	2		2	1	1			1
CO 5	3	3	2	2		2	1	1	3		1

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/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 (8 hours)

Fundamentals of HVDC Transmission

Introduction to HVDC - historical developments, principle, advantages, disadvantages, comparison of AC and DC transmission systems - economic, technical performance, reliability, types of HVDC Systems, planning for HVDC transmission - choice of voltage level, modern trends in DC transmission.

MODULE 2 (9 hours)

HVDC Converters

Role of converters in HVDC systems, basic principle of AC-DC conversion, Gratez circuit - analysis without overlap, with overlap (firing angle $< 60^\circ$), multibridge converters, rectifier and inverter stations - layout.

MODULE 3 (10 hours)

HVDC Control Techniques

Need for control in HVDC systems, principles of DC Link control, converter control - basic characteristics, firing angle control, current and extinction angle control, power control, various higher-level controllers - emergency control, reactive power control, sub synchronous damping control.

MODULE 4 (9 hours)

Protection of HVDC Systems

Concept of protection in HVDC transmission systems - importance for system reliability, converter faults in HVDC systems, protection against overcurrents and over voltages, over voltages in converter stations, surge arrestors, protection practices adopted in practical HVDC installations.

MODULE 5 (9 hours)

HVDC System Elements & Harmonic Filters

Major components of HVDC systems - converter transformers, smoothing reactors, filters, DC transmission lines and cables, role of HVDC in renewable energy integration and interconnection of power grids. Harmonics - characteristic harmonics, uncharacteristic har-

monics, presence of triplen harmonics in DC voltage, types of filters - passive filters, active filters, case studies of existing HVDC projects in India (Assignment only).

Text Books

1. Kimbark, E. W, *Direct Current Transmission.*, Vol. I, Wiley-IEEE Press, Reprint ed., 2019.
2. Padiyar, K. R. , *HVDC Power Transmission Systems: Technology and System Interactions*, New Age International Publishers, 2nd ed., 2017.
3. Arrillaga, J., Liu, Y. H., Watson, N. R., *Flexible Power Transmission: The HVDC Options*, Wiley, 2nd ed., 2018
4. Rao, S., *EHV-AC, HVDC Transmission & Distribution Engineering*, Khanna Publishers, 3rd ed, 2015.
5. Kundur P, *Power System Stability and Control*, McGraw-Hill Education, 2nd ed., 2021.

Reference Books

1. Weedy, B. M., Cory, B. J., Jenkins, N., Ekanayake, J. B., Strbac, G., *Electric Power Systems*, Wiley, 6th ed., 2020.
2. Sood, V. K., *HVDC and FACTS Controllers: Applications of Static Converters in Power Systems*, Springer, 2020.
3. Padiyar, K. R., Prabhu, N., *Dynamics of Power Systems with FACTS Controllers*, Wiley, 2nd ed., 2020.
4. Dragan Jovicic & Khaled Ahmed, *High Voltage Direct Current Transmission: Converters, Systems and DC Grids*, Wiley, 2nd ed., 2019.
5. IEEE Power & Energy Society, *HVDC Transmission and Distribution Handbook*, IEEE Press, 2021.
6. X. Liang and M. Abbasipour, *HVDC Transmission and its Potential Application in Remote Communities: Current Practice and Future Trend*, IEEE Press, 2021.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Fundamentals of HVDC Transmission	8
1.1	Introduction to HVDC, historical developments, principle,	1
1.2	Advantages, disadvantages, comparison of AC and DC transmission systems - economic, technical performance, reliability	2
1.3	Types of HVDC Systems	1
1.4	Planning for HVDC transmission - choice of voltage level	2
1.5	Modern trends in DC transmission	2
	Module 2: HVDC Converters	9
2.1	Role of converters in HVDC systems- basic principle of AC-DC conversion	2
2.2	Gratez circuit - analysis without overlap	2
2.3	Gratez circuit- analysis with overlap (firing angle $< 60^\circ$)	2
2.4	Multibridge converters	1
2.5	Rectifier and inverter stations - layout.	2
	Module 3: HVDC Control Techniques	10
3.1	Need for control in HVDC systems, principles of DC Link control	1
3.2	Converter control - basic characteristics, firing angle control	2
3.3	Current and extinction angle control, power control	2
3.4	Power control	1
3.5	Various higher-level controllers - emergency control, reactive power control	2
3.6	Various higher-level controllers - sub synchronous damping control.	2
	Module 4: Protection of HVDC Systems	9
4.1	Concept of protection in HVDC transmission- importance for system reliability	1
4.2	Converter faults in HVDC systems	2
4.3	Protection against over-currents and over voltages	2
4.4	Over voltages in converter stations, surge arrestor	2
4.5	Protection practices adopted in practical HVDC installations	2

	Module 5: HVDC System Elements & Harmonic Filters	9
5.1	Major components of HVDC systems - converter transformers, smoothing reactors, filters, DC transmission lines and cables	2
5.2	role of HVDC in renewable energy integration and inter-connection of power grids.	2
5.3	Harmonics - characteristic harmonics, uncharacteristic harmonics	2
5.4	Presence of triplen harmonics in DC voltage, types of filters - passive filters, active filters	2
5.5	Case studies of existing HVDC projects in India.	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the need for long distance HVDC transmission and compare its performance with HVAC systems in terms of losses and stability.
2. Compare HVDC and AC transmission systems based on efficiency, controllability, cost, and application areas.
3. Describe the basic operating principle of HVDC transmission and illustrate different configurations such as monopolar, bipolar, and back-to-back systems.

Course Outcome 2 (CO 2)

1. Explain the operating principle of HVDC converters and differentiate between rectifier and inverter modes of operation.
2. Describe different HVDC converter configurations such as line-commutated converters (LCC) and voltage-source converters (VSC).
3. Analyze the performance characteristics of HVDC converters, including commutation, power factor, and harmonic generation.

Course Outcome 3 (CO 3)

1. Explain the concept of DC link control in HVDC systems and its role in maintaining power flow stability.

2. Analyze converter control strategies such as firing angle control and extinction angle control in HVDC systems.
3. Discuss higher-level control strategies (e.g., power control, frequency control) used to ensure reliable and stable HVDC operation.

Course Outcome 4 (CO 4)

1. Explain the importance of protection in HVDC systems and compare it with protection requirements in AC systems.
2. Identify and describe common fault types in HVDC transmission systems, such as DC line faults and converter faults.
3. Discuss protection techniques used in HVDC systems, including fault detection, isolation, and use of DC circuit breakers.

Course Outcome 5 (CO 5)

1. Describe the main components of an HVDC system and explain their roles in power transmission.
2. Analyze the harmonic generation in HVDC systems and discuss methods used for harmonic mitigation.
3. Explain how HVDC systems support renewable energy integration, particularly in connecting offshore wind farms and remote solar plants.

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EEM72

Course Name: : HVDC TRANSMISSION

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define HVDC transmission and list two advantages over AC transmission.
2. Explain the basic principle of HVDC transmission.
3. State the role of converters in HVDC transmission systems.
4. Explain the basic principle of AC-DC conversion.
5. State the need for control in HVDC systems.
6. Explain the basic characteristics of converter control
7. Analyze the need for surge arrestors in converter stations.
8. Define protection in HVDC transmission systems.
9. Explain the function of smoothing reactors.
10. List the major components of an HVDC transmission system.

PART B

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

11. (a) Describe the historical development of HVDC transmission systems. (7 marks)
(b) Explain the advantages and disadvantages of HVDC transmission. (7 marks)

OR

12. (a) Discuss different types of HVDC transmission systems with suitable diagrams. (7 marks)
(b) Explain the planning considerations for HVDC transmission including the choice of voltage level. (7 marks)
13. (a) Explain the working of the Graetz circuit without overlap. (7 marks)
(b) Analyze the operation of a Graetz circuit with overlap when firing angle $< 60^\circ$. (7 marks)

OR

14. (a) Describe the concept and advantages of multibridge converters. (7 marks)
(b) Explain the layout of rectifier and inverter stations in HVDC transmission. (7 marks)
15. (a) Explain the principles of DC link control in HVDC systems. (7marks)
(b) Describe higher-level control strategies such as emergency control and reactive power control. (7 marks)

OR

16. Discuss firing angle control and extinction angle control techniques. Also, explain the power control methods used in HVDC transmission. (14 marks)
17. Explain the importance of reliability protection in HVDC systems. Also, describe practical protection practices adopted in HVDC installations. (14 marks)

OR

18. (a) Explain the overvoltage protection methods used in the converter stations. (7 marks)
(b) Discuss protection against overcurrents in HVDC transmission systems. (7 marks)

19. (a) Explain the working of converter transformers in HVDC systems. (7 marks)
(b) Discuss the role of filters in reducing harmonics in HVDC systems. system given below. (7 marks)

OR

20. (a) Explain passive and active harmonic filters with suitable examples. (7 marks)
(b) Describe the role of HVDC transmission in renewable energy integration. (7 marks)



B24EEM73	DISTRIBUTED GENERATION AND SMART GRID	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

The course aims to provide a comprehensive understanding of distributed generation, micro-grids, and smart grid technologies used in modern power systems. It covers the integration, control, protection, and economic aspects of distributed energy resources along with smart grid architecture, communication, and emerging technologies. By the end of the course, students will be able to analyse and evaluate microgrid and smart grid systems for efficient, reliable, and sustainable energy management.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the concepts and operating principles of distributed energy resources such as CHP systems, solar PV, wind energy conversion systems, small-scale hydro, and energy storage devices. (Cognitive Knowledge Level: Understand)
CO 2	Explain the structure, configurations, control strategies, and protection requirements of microgrids, including islanding scenarios and interconnection of micro-grids. (Cognitive Knowledge Level: Understand)
CO 3	Understand the technical, economic, environmental, and market impacts of distributed generation and microgrid integration on power systems, including communication standards and protocols. (Cognitive Knowledge Level: Understand)
CO 4	Understand smart grid technologies such as smart meters, pricing mechanisms, automation systems, and advanced measurement devices in power system operation. (Cognitive Knowledge Level: Understand)
CO 5	Analyse energy management, demand-side management, and advanced metering and communication infrastructures for improving system efficiency and reliability. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	40	40	20
Understand	60	60	40
Apply			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 (8 hours)

Distributed Energy Resources

Introduction, combined heat and power (CHP) systems, solar photovoltaic (PV) systems, wind energy conversion systems (WECS) - constant speed wind turbine, variable speed wind turbine, small-scale hydroelectric power generation. Storage devices - batteries, ultra-capacitors, flywheels.

MODULE 2 (10 hours)

Micro Grids Control and Protection

Micro Grids - integration of distributed generation, typical configurations - AC, DC and hybrid micro grids. Interconnection of microgrids, technical and economic advantages, challenges, disadvantages. Control of microgrids - central controller (CC), micro-source controllers (MCs), Protection issues for microgrids - islanding, islanding scenarios. Impact of DG integration - electricity market, environment, distribution system. Communication standards and protocols.

MODULE 3 (8 hours)

Introduction to Smart Grid

Evolution of electric grid, definitions, need, smart grid drivers, functions of smart grid, opportunities and barriers of smart grid, difference between conventional grid and smart grid, concept of resilient and self-healing grid. Components and architecture, inter-operability, impacts of smart grid on system reliability, present development and international policies in smart grid, smart grid standards.

MODULE 4 (9 hours)

Smart Grid Technologies

Introduction to smart meters, electricity tariff, dynamic pricing - time of-use (TOU) pricing, critical-peak pricing (CPP), real time pricing. Automatic meter reading (AMR), plug-in hybrid electric vehicles (PHEV), vehicle to grid, smart sensors, home and building automation, intelligent electronic devices (IED), wide area measurement system (WAMS), phase measurement unit (PMU).

MODULE 5 (10 hours)

Smart Grid Communication Technologies and Energy Management

Advanced metering infrastructure (AMI), home area network (HAN), neighbourhood-area networks (NANs), sensor and actuator networks (SANETs), cloud computing in smart grid - private cloud, public cloud, hybrid cloud. Cloud architecture of smart grid. Smart energy-efficient end-use devices, load shaping objectives and methodologies - numerical problems, energy management, role of technology in demand response, demand side management.

Text Books

1. Radian Belu, *Smart Grid Fundamentals: Energy Generation, Transmission and Distribution*, CRC Press, 1st ed., 2022.
2. VG V. Indra Gandhi, *Smart Energy Management for Microgrid and Photovoltaic Systems*, MDPI Books, 1st ed., 2023.
3. Ali Keyhani, *Design of Smart Power Grid Renewable Energy Systems*, Wiley, 3rd ed., 2019.
4. James Momoh, *Smart Grid: Fundamentals of Design and Analysis*, Wiley-IEEE Press, 1st ed., 2012.
5. R. C. Dugan, M. F. McGranaghan, H. W. Beaty, *Electrical Power Systems Quality*, McGraw-Hill, 3rd ed., 2012.

Reference Books

1. S. Chowdhury, S.P. Chowdhury and P. Crossley, *Microgrids and Active Distribution Networks*, IET, 1st ed., 2009.
2. Remus Teodorescu, Marco Liserre, Pedro Rodriguez, *Grid Converters for Photovoltaic and Wind Power Systems*, Wiley-IEEE Press, 1st ed., 2011.
3. N. Jenkins, Janaka Ekanayake and G. Strbac, *Distributed Generation*, IET Press, 1st ed., 2010.
4. Math H. Bollen and Fainan Hassan, , *Integration of Distributed Generation in the Power System*, WJohn Wiley & Sons, 1st ed., 2011.
5. Gregory W. Massey, *Essentials of Distributed Generation Systems*, Jones & Bartlett Publishers, 1st ed., 2010.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Distributed Energy Resources	8
1.1	Introduction, combined heat and power (CHP) systems, solar photovoltaic (PV) systems.	2
1.2	Wind energy conversion systems (WECS) - constant speed wind turbine, variable speed wind turbine.	2
1.3	Small-scale hydroelectric power generation.	2
1.4	Storage devices - batteries, ultra-capacitors, flywheels.	2
	Module 2: Micro Grids Control and Protection	10
2.1	Micro Grids - integration of distributed generation, typical configurations - AC, DC and hybrid micro grids.	2
2.2	Interconnection of microgrids, technical and economic advantages, challenges, disadvantages.	2
2.3	Control of microgrids - central controller (CC), micro-source controllers (MCs).	2
2.4	Protection issues for microgrids - islanding, islanding scenarios.	2
2.5	Impact of DG integration - electricity market, environment, distribution system.	1
2.6	Communication standards and protocols.	1
	Module 3: Introduction to Smart Grid	8
3.1	Evolution of electric grid, definitions, need, smart grid drivers.	2
3.2	Functions of smart grid, opportunities and barriers of smart grid, difference between conventional grid and smart grid.	2
3.3	Concept of resilient and self- healing grid. Components and architecture, inter-operability.	2
3.4	Impacts of smart grid on system reliability, present development and international policies in smart grid, smart grid standards.	2
	Module 4: Smart Grid Technologies	9
4.1	Introduction to smart meters, electricity tariff.	1
4.2	Dynamic pricing - time of-use (TOU) pricing, critical-peak pricing (CPP), real time pricing.	2
4.3	Automatic meter reading (AMR), plug-in hybrid electric vehicles (PHEV)	2
4.4	Vehicle to grid, smart sensors, home and building automation.	2
4.5	Intelligent electronic devices (IED), wide area measurement system (WAMS), phase measurement unit (PMU).	2

	Module 5: Smart Grid Communication Technologies and Energy Management	10
5.1	Advanced metering infrastructure (AMI), home area network (HAN).	2
5.2	Neighbourhood-area networks (NANs), sensor and actuator networks (SANETs).	2
5.3	Cloud computing in smart grid - private cloud, public cloud, hybrid cloud. Cloud architecture of smart grid.	2
5.4	Smart energy-efficient end-use devices, load shaping objectives and methodologies - numerical problems.	2
5.5	Energy management, role of technology in demand response, demand side management.	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the working principle of a combined heat and power (CHP) system and discuss its advantages over conventional power generation.
2. Describe the operation of a solar photovoltaic (PV) system.
3. Differentiate between constant speed and variable speed wind turbines.

Course Outcome 2 (CO 2)

1. Explain the structure and configurations of AC, DC, and hybrid microgrids with suitable diagrams.
2. Describe the control strategies used in microgrids.
3. Discuss islanding in microgrids, its types, and protection challenges associated with it.

Course Outcome 3 (CO 3)

1. Define a smart grid and explain its need compared to conventional power grids.
2. Discuss the technical, economic, and environmental impacts of distributed generation on power systems.
3. Explain the concept of a self-healing and resilient grid, and describe the role of communication standards in smart grid operation.

Course Outcome 4 (CO 4)

1. Explain the working of smart meters and discuss different electricity pricing mechanisms such as TOU, CPP, and real-time pricing.
2. Describe the concept of plug-in hybrid electric vehicles (PHEV).
3. Discuss the role of Phasor Measurement Units (PMU) and Wide Area Measurement Systems (WAMS) in modern power systems.

Course Outcome 5 (CO 5)

1. Explain the architecture and functions of Advanced Metering Infrastructure (AMI) and its role in smart grids.
2. Describe demand-side management (DSM) and explain different load shaping techniques with examples.
3. A consumer has varying load demands over a day. Formulate a load shifting strategy using time-of-use pricing and explain how it improves system efficiency.

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EEM73

Course Name: : DISTRIBUTED GENERATION AND SMART GRID

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define Distributed Energy Resources (DER) and give two examples.
2. What is the function of an inverter in a solar PV system?
3. State the difference between constant speed and variable speed wind turbines.
4. What is a microgrid? Mention its types.
5. Define islanding in microgrids.
6. Define smart grid concept and explain its necessity.
7. List any two advantages of smart grid over conventional grid.
8. What is Critical Peak Pricing (CPP)?
9. What is the purpose of a Phasor Measurement Unit (PMU)?
10. Define load shaping in demand-side management.

PART B

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

11. (a) Explain the working of a solar photovoltaic (PV) system with a neat diagram. (7 marks)
- (b) Describe the operation and advantages of Combined Heat and Power (CHP) systems. (7 marks)

OR

12. (a) Explain Wind Energy Conversion Systems (WECS) and compare constant and variable speed wind turbines. (7 marks)
- (b) Discuss different energy storage devices used in distributed generation such as batteries, ultra-capacitors, and flywheels. (7 marks)
13. (a) Explain the structure and configuration of AC, DC, and hybrid microgrids. (7 marks)
- (b) Describe the control strategies in microgrids, including CC and MCs. (7 marks)

OR

14. (a) Explain islanding in microgrids and its different scenarios. (7 marks)
- (b) Discuss the protection issues and challenges in microgrids. (7 marks)
15. (a) Explain the evolution of the electric grid and the need for smart grids. (7 marks)
- (b) Discuss the functions and features of a smart grid, including self-healing capability. (7 marks)

OR

16. (a) Compare conventional grid and smart grid in terms of operation and efficiency. (7 marks)
- (b) Explain the technical, economic, and environmental impacts of distributed generation. (7 marks)
17. (a) Explain the working of smart meters and different pricing mechanisms. (7 marks)
- (b) Describe the concept of Plug-in Hybrid Electric Vehicles (PHEV) and Vehicle-to-Grid (V2G). (7 marks)

OR

18. (a) Explain the role of Phasor Measurement Units (PMU) in power systems. (6 marks)
- (b) Discuss Wide Area Measurement Systems (WAMS) and intelligent electronic devices (IEDs). (8 marks)

19. (a) Explain the architecture and functions of Advanced Metering Infrastructure (AMI). (6 marks)
- (b) Describe Home Area Network (HAN), Neighbourhood Area Network (NAN), and cloud computing in smart grid. (8 marks)

OR

20. (a) Explain Demand Side Management (DSM) and load shaping techniques. (7 marks)
- (b) A consumer shifts load from peak hours to off-peak hours under TOU pricing. Explain how this improves system efficiency with suitable analysis. (7 marks)



HONOURS

B24EEH71	DYNAMICS OF POWER CONVERTERS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course aims to provide a comprehensive understanding of dynamic modeling, small-signal analysis, and control design techniques for basic DC-DC power converters. It covers steady-state analysis and equivalent circuit modeling, advanced AC small-signal modeling methods (including state-space averaging, circuit averaging, and averaged switch modeling), development of canonical models, derivation of key transfer functions, and practical controller design using classical compensators such as PD, PI, and PID. On completion of the course, participants will be able to construct precise small-signal models of DC-DC converters, analyze and interpret their frequency-domain transfer functions using Bode plots, design stable and high-performance feedback controllers.

Prerequisites

Power Electronics

Course Outcomes

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

CO 1	Analyze and model the steady-state operation of basic DC-DC converters in CCM operation and apply the principle to any DC-DC converter topologies. (Cognitive Knowledge Level: Apply)
CO 2	To develop small-signal AC models of basic PWM DC-DC converters operating in continuous conduction mode. (Cognitive Knowledge Level: Apply)
CO 3	To derive and apply advanced small-signal modeling techniques for PWM DC-DC converters. (Cognitive Knowledge Level: Apply)
CO 4	To analyze the frequency-domain behaviour of PWM DC-DC converters in continuous conduction mode. (Cognitive Knowledge Level: Apply)
CO 5	To design effective and robust feedback controllers applicable to any basic PWM DC-DC converter. (Cognitive Knowledge Level: Analyze)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	3	3							3
CO 2	3	3	3	3	1						3
CO 3	3	3	3	3	1						3
CO 4	3	3	3	3	1						3
CO 5	3	3	3	3	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/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)

Steady State Modelling

Overview of basic DC-DC converters - buck, boost and buck-boost converter, principle of steady state converter analysis, small signal ripple approximation. Steady state equivalent circuit modeling - DC transformer model, inductor copper loss, efficiency, obtaining input port of the model, inclusion of semiconductor conduction losses in converter model.

MODULE 2 (10 hours)

AC Equivalent Circuit Modeling and State-Space Averaging

Basic AC modelling approach, averaging approximation - inductor and capacitor waveforms, perturbation and linearization, small signal equivalent circuit model, State-Space averaging - state equations of switching converters, basic state space averaged model, State-space averaging of basic DC-DC converters (buck, boost, buck-boost).

MODULE 3 (10 hours)

Circuit Averaging, Averaged Switch Modeling, and Canonical Model

Circuit averaging, obtaining a time-invariant averaged circuit, perturbation and linearization, switch networks, averaged switch modelling of basic DC-DC converters, averaged switch modelling including conduction and switching losses, Canonical circuit model- development of canonical circuit model for basic DC-DC converters, parameter values for basic converters in canonical form, comparison of state-space averaging, circuit averaging, and canonical model, modelling the pulse width modulator.

MODULE 4 (8 hours)

Converter Transfer Functions

Review of frequency response analysis techniques - Bode plots, converter transfer functions - graphical construction. Converter transfer functions of ideal buck, boost and buck-boost converters, measurement of AC transfer functions and impedances.

MODULE 5 (8 hours)

Controller Design

Effect of negative feedback on the network transfer functions - loop transfer function Controller design specifications - PD, PI and PID compensators, applications to the basic dc-dc topologies, practical methods to measure loop gains - voltage and current injection.

Text Books

1. Robert Erickson and Dragan Maksimovic, William P. Robbins, *Fundamentals of Power Electronics*, Springer India, 2nd ed., 2002.
2. Christophe P. Basso, *Switched Mode Power Supplies: SPICE Simulations and Practical Designs*, McGrawhill, 2nd ed., 2014.
3. John. G. Kassakian, M. F. Schlecht, G. C. Verghese, *Principles of Power Electronics*, Pearson Education, 2nd ed., 2010.
4. Ned Mohan, T. M. Undeland, W. P. Robbins, *Power electronics converters, applications and design*, John Wiley and Sons Ltd, 3rd ed., 2014.
5. L. Umanand, *Power Electronics: Essentials and Applications*, Wiley India Pvt. Ltd., 1st ed., 2009.

Reference Books

1. V. Ramanarayanan, *Switched Mode Power Conversion*, Course text / academic text-book material, Indian Institute of Science, Bangalore, 2007.
2. M. H. Rashid, *Power Electronics: Circuits, Devices and Applications*, PHI/Pearson, 4th ed., 2017.
3. Philip T. Krein, *Elements of Power Electronics*, Oxford University Press, 1st ed., 1998.
4. Texas Instruments Incorporated, *Application Notes and Reference Designs in Power Electronics*, URL: <https://www.ti.com>.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Steady State Modelling	9
1.1	Overview of basic DC-DC converters - buck, boost and buck-boost converter	2
1.2	Principle of steady state converter analysis.	1
1.3	Inductor volt-second, capacitor charge balance and small signal ripple approximation.	1
1.4	Steady state equivalent circuit modeling-DC transformer model.	2
1.5	Inductor copper loss, efficiency.	1
1.6	Obtaining input port of the model.	1
1.7	inclusion of semiconductor conduction losses in converter model.	1

	Module 2: AC Equivalent Circuit Modeling and State-Space Averaging	10
2.1	Basic AC modelling approach.	1
2.2	Averaging, approximation - inductor and capacitor wave-forms.	1
2.3	Perturbation and linearization.	1
2.4	Small signal equivalent circuit model.	1
2.5	State-space averaging.	1
2.6	state equations of switching converters.	2
2.7	Basic state space averaged model.	1
2.8	State-space averaging of basic DC-DC converters (buck, boost, buck-boost).	2
	Module 3: Circuit Averaging, Averaged Switch Modeling, and Canonical Model	10
3.1	Circuit averaging, obtaining a time-invariant averaged circuit.	2
3.2	Perturbation and linearization	1
3.3	Switch networks, averaged switch modelling of basic DC-DC converters	1
3.4	averaged switch modelling including conduction and switching losses.	1
3.5	Canonical circuit model - development of canonical circuit model for basic DC-DC converters.	2
3.6	Parameter values for basic converters in canonical form	1
3.7	Comparison of state-space averaging, circuit averaging, and canonical model.	1
3.8	Comparison of state-space averaging, circuit averaging, and canonical model.	1
	Module 4: Converter Transfer Functions	8
4.1	Review of frequency response analysis techniques.	2
4.2	Bode plots - converter transfer functions - graphical construction.	2
4.3	Converter transfer functions of ideal buck, boost and buck-boost converters	2
4.4	Measurement of AC transfer functions and impedances.	2
	Module 5: Controller Design	8
5.1	Effect of negative feedback on the network transfer functions.	1
5.2	Loop transfer function, controller design specifications.	2
5.3	PD, PI and PID compensators.	2
5.4	Applications to the basic DC-DC topologies.	1
5.5	Practical methods to measure loop gains - voltage and current injection.	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. State and explain the inductor volt-second balance principle for steady-state operation of DC-DC converters.
2. Explain the capacitor charge balance principle.
3. What is the small-signal ripple approximation?
4. Draw and explain the ideal DC transformer model for a buck-boost converter.

Course Outcome 2 (CO 2)

1. Define state-space averaging and explain its significance in modelling switched-mode power converters.
2. What is meant by linearization of a nonlinear SMPC model? Why is it required for control design?
3. Define small-signal approximation in SMPS control.

Course Outcome 3 (CO 3)

1. Explain the principle of circuit averaging in switched-mode power converters.
2. Describe the step-by-step procedure to obtain a time-invariant averaged circuit model from a switching converter.
3. What assumptions are made when applying circuit averaging.

Course Outcome 4 (CO 4)

1. Describe the effect of a right-half-plane zero on the magnitude and phase plots compared to a left-half-plane zero.
2. Why is graphical construction particularly useful for design-oriented analysis of converter transfer functions.
3. Compare the salient features of the control-to-output transfer functions for ideal CCM Buck, Boost, and Buck-Boost converters.

Course Outcome 5 (CO 5)

1. Describe a step-by-step experimental procedure to measure loop gain of a Boost converter.
2. Discuss practical challenges in loop gain measurement for switching converters.
3. Compare voltage injection and current injection methods for loop gain measurement.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EEH71

Course Name: : DYNAMICS OF POWER CONVERTERS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Discuss the importance of small-signal ripple approximation in converter analysis.
2. Explain how semiconductor conduction losses are incorporated in the steady-state model.
3. Define perturbation and linearization.
4. Explain the averaging approximation technique using the inductor current and capacitor voltage waveforms of a buck converter in CCM.
5. Explain the circuit averaging technique for obtaining a time-invariant averaged circuit of a buck converter in CCM.
6. Draw the averaged switch model (including conduction losses) for a buck converter.
7. Derive the control-to-output transfer function $G_{vd}(s)$ for an ideal buck converter in CCM using the small-signal model.
8. Explain the physical origin of the RHP zero in Boost and Buck-Boost converters and its impact on achievable control bandwidth.
9. Write the time-domain and s-domain transfer functions for (i) Proportional (P), (ii) Proportional-Integral (PI), (iii) Proportional-Derivative (PD), and (iv) PID controllers.
10. Why is a pure derivative term (D) rarely used in DC-DC converters?

PART B

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

11. A buck converter operates with $V_{in} = 24$ V, $L = 100$ H, $C = 100$ F, $R = 10$ Ω , and switching frequency $f_s = 100$ kHz. Assuming continuous conduction mode (CCM), derive the steady-state output voltage V_{out} using the inductor volt-second balance principle. Then apply the same principle to find the minimum inductance required to maintain CCM at duty cycle $D = 0.5$. (14 marks)

OR

12. Compare the steady-state operation of buck, boost, and buck-boost converters in CCM using volt-second balance and capacitor charge balance. Derive the voltage conversion ratio and average inductor current for each converter. Highlight the polarity inversion in buck-boost and its effect on the DC transformer model. (14 marks)
13. Draw the small-signal equivalent circuit model of a buck converter using the basic AC modelling approach. and derive the control-to-output transfer function. (14 marks)

OR

14. Derive the small-signal AC equivalent circuit model of a boost converter using the averaging approximation and linearization. Include the effect of duty-cycle perturbation $\hat{d}$ as a controlled voltage source. From this circuit, obtain the expressions for input-to-output transfer function $G_{vg}(s)$ and control-to-output transfer function $G_{vd}(s)$. (14 marks)
15. Develop the canonical circuit model for a boost converter. Show step-by-step how the averaged switch model is transformed into the canonical form (14 marks)

OR

16. Compare state-space averaging, circuit averaging, and the canonical circuit model for any basic DC-DC converter. (14 marks)
17. For a second-order low-pass transfer function of the form $1/(1 + s/Q\omega_o + s^2/\omega_o^2)$, sketch the approximate Bode magnitude and phase plots, labeling the resonant frequency and quality factor Q effects. (14 marks)

OR

18. How do the locations of the complex poles (resonant frequency ω_o) compare among Buck, Boost, and Buck-Boost converters (assuming same L, C, and load R)? (14 marks)
19. For an ideal CCM Buck converter, design a PI controller to achieve a crossover frequency of $f_c = f_s w/10$ and phase margin $\geq 50^\circ$. Discuss how the compensator zeros/poles are placed relative to the LC double pole. (14 marks)

OR

20. Compare controller design challenges for Buck, Boost and Buck-Boost converters, focusing on pole/zero locations and the impact on achievable bandwidth. (14 marks)

B24EEH72	CONTROL AND DYNAMICS OF MICROGRID	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5		

Preamble

The objective of the course is to introduce the fundamentals of microgrids, covering their architecture, modelling, control, protection, and economic aspects. The course covers modelling of distributed generation (DG) units, energy storage systems, and converters, followed by hierarchical and droop control techniques for both grid-connected and islanded operations. On successful completion of the course, students will be able to understand control strategies, protection schemes, and microgrid economics.

Prerequisites

Power Systems, Control Systems, Power Electronics

Course Outcomes

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

CO 1	Understand microgrid concepts, architectures, and components. (Cognitive Knowledge Level: Understand)
CO 2	Analyse and develop dynamic state-space models of microgrid components, including photovoltaic systems, lead-acid batteries, supercapacitors, and power electronic converters. (Cognitive Knowledge Level: Analyze)
CO 3	Analyse hierarchical microgrid control and explain droop control characteristics in conventional power systems and inverter-based distributed generators for effective power management (Cognitive Knowledge Level: Analyze)
CO 4	Understand the challenges and islanding scenarios in microgrid protection and explain conventional and advanced protection schemes. (Cognitive Knowledge Level: Understand)
CO 5	Understand the economic issues of microgrids and apply renewable generation and load forecasting techniques to develop energy management strategies. (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			2		1			1
CO 2	3	2	2	1		2		1			1
CO 3	3	1	1			3					1
CO 4	3	1	2	1		3					1
CO 5	3	2		1		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	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)

Introduction to Microgrids

Microgrid concept, application, technical and economical advantages of microgrid, challenges and disadvantages, modes of operation - grid connected, islanded. Microgrid components - distributed generation, energy storage systems, power conversion system, controllers and energy management system, communication system, loads, protection system. Microgrid architectures - AC, DC, hybrid.

MODULE 2 (9 hours)

Modelling of Microgrid

Overall representation of the grid-connected microgrid, microgrid components dynamics and modelling - PV Model, power electronic converters, energy storage systems - lead-acid battery, supercapacitor. State space dynamic model of microgrid, power electronic interfaces.

MODULE 3 (9 hours)

Microgrid Control Strategies

Hierarchical control levels in microgrids, microgrid control hierarchy - local control, secondary control, central/emergency control, global control. Droop control - droop characteristic in conventional power systems, droop control in inverter-based distributed generators, virtual impedance control. Hierarchical power management and control.

MODULE 4 (9 hours)

Microgrid Protection

Challenges for microgrid protection, different islanding scenarios, major protection issues of stand-alone microgrid - microgrid distribution system protection, protection of microsources, NEC requirements for distribution transformer protection. Protection system for microgrids - overcurrent protection, differential protection, distance protection, voltage-based protection, adaptive protection, machine learning based protection schemes.

MODULE 5 (9 hours)

Microgrid Economics

Main issues of microgrid economics, emerging economic issues in microgrids, classification of renewable generation forecasting, short-term renewable generation and load forecasting

techniques - physical models, time series methods. Factors affecting forecasting accuracy, causes of uncertainty. Energy management in microgrid - daily power management and setting of power references, medium-term energy management, short term power management.

Text Books

1. H. Bevrani, B. François, T. Ise, *Microgrid Dynamics and Control*, John Wiley & Sons, 1st ed., 2017
2. N. D. Hatziargyriou, *Microgrids Architecture and control*, IEEE Press Series, John Wiley & Sons Inc, 1st ed., 2014.
3. D. Zheng, W. Zhang, S. Netsanet, P. Wang, G. T. Bitew, D. Wei, and J. Yue , *Microgrid Protection and Control*, Academic Press, 1st ed., 2021
4. S. Chowdhury, S. P. Chowdhury, and P. Crossley, *Microgrids and Active Distribution Networks*, London, U.K., Institution of Engineering and Technology 1st ed., 2009.

Reference Books

1. M. H. Rashid, *Power Electronics Handbook*, Academic Press, 4th ed., 2017
2. F. Katiraei, R. Iravani, N. Hatziargyriou, and A. Dimeas, *Microgrids Management*, IEEE Press Series, John Wiley & Sons Inc, 1st ed., 2008.
3. J. M. Guerrero, P. C. Loh, T. L. Lee, and M. Chandorkar *Advanced Control of Microgrids with Distributed Energy Resources*, Wiley-IEEE Press, 1st ed., 2016
4. Magdi S. Mahmoud, *Microgrid: Advanced Control Methods and Renewable Energy System Integration*, Elsevier, 1st ed., 2017.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Introduction to Microgrids	9
1.1	Microgrid concept, application, technical and economical advantages of microgrid, challenges and disadvantages	2
1.2	Modes of operation - grid connected, islanded	1
1.3	Microgrid components - distributed generation, energy storage systems	1

1.4	Power conversion system, controllers and energy management system	2
1.5	Communication system, loads, protection system	2
1.6	Microgrid architectures - AC, DC, hybrid	1
	Module 2: Modelling of Microgrid	9
2.1	Overall representation of the grid-connected microgrid	1
2.2	Microgrid components dynamics and modelling - PV Model	1
2.3	Microgrid components dynamics and modelling -power electronic converters	2
2.4	Energy storage systems - lead-acid battery, supercapacitor	2
2.5	State space dynamic model of microgrid	2
2.6	Power electronic interfaces	1
	Module 3: Microgrid Control Strategies	9
3.1	Hierarchical control levels in microgrids	1
3.2	Microgrid control hierarchy - local control, secondary control, central/emergency control, global control	2
3.3	Droop control - droop characteristic in conventional power systems	2
3.4	Droop control in inverter-based distributed generators, virtual impedance control	2
3.5	Hierarchical power management and control	2
	Module 4: Microgrid Protection	9
4.1	Challenges for microgrid protection, different islanding scenarios, major protection issues of stand-alone microgrid	1
4.2	Microgrid distribution system protection, protection of microsources	1
4.3	NEC requirements for distribution transformer protection	1
4.4	Protection system for microgrids - overcurrent protection	1
4.5	Differential protection	1
4.6	Distance protection	1
4.7	Voltage-based protection	1
4.8	Adaptive protection	1
4.9	Machine learning based protection schemes	1
	Module 5: Microgrid Economics	9
5.1	Main issues of microgrid economics, emerging economic issues in microgrids	1
5.2	Classification of renewable generation forecasting, short-term renewable generation and load forecasting techniques - physical models, time series methods	2
5.3	Factors affecting forecasting accuracy, causes of uncertainty	2
5.4	Energy management in microgrid - daily power management and setting of power references	2
5.5	Medium-term energy management, short term power management.	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the concept of a microgrid.
2. Give examples of AC, DC, and hybrid microgrid architectures.
3. Describe the advantages of microgrids.

Course Outcome 2 (CO 2)

1. Explain the importance of microgrid modelling.
2. Describe the modelling of a lead-acid battery.
3. Describe the overall representation of a grid-connected microgrid.

Course Outcome 3 (CO 3)

1. Explain the hierarchical control levels in microgrids.
2. Describe virtual impedance control.
3. Explain droop control used in inverter-based DGs.

Course Outcome 4 (CO 4)

1. List different islanding scenarios.
2. State any two protection issues in stand-alone microgrids.
3. Describe protection issues in stand-alone microgrids.

Course Outcome 5 (CO 5)

1. Define renewable generation forecasting in microgrids.
2. Describe time-series methods in microgrids.
3. Identify factors affecting forecasting accuracy in microgrids.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EEH72

Course Name: : CONTROL AND DYNAMICS OF MICROGRID

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Differentiate between grid-connected and islanded operation.
2. List the components of a microgrid and their functions
3. List the key parameters for modelling a supercapacitor.
4. Explain the purpose of power electronic interfaces in microgrid.
5. State the purpose of central/emergency control.
6. Explain the need for secondary control.
7. Compare overcurrent and differential protection.
8. Explain NEC requirements for transformer protection.
9. Explain short-term load forecasting in microgrids.
10. List techniques for uncertainty reduction in microgrids.

PART B

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

11. Describe AC and DC microgrid configurations and explain the roles of its major components. (14 marks)

OR

12. Explain the grid-connected and islanded modes of microgrid operation in detail with examples. (14 marks)
13. Develop state-space equations for a lead-acid battery and a supercapacitor. (14 marks)

OR

14. Develop the mathematical model of a photovoltaic (PV) system. (14 marks)
15. (a) Describe virtual impedance control in detail. (9 marks)
(b) Describe stability issues in microgrid control. (5 marks)

OR

16. Discuss the state-space dynamic model of a grid-connected microgrid with diagrams. (14 marks)
17. Illustrate the hierarchical control levels in microgrids. (14 marks)

OR

18. Describe the different protection systems in microgrid. (14 marks)
19. Discuss the main issues of microgrid economics. (14 marks)

OR

20. Explain how energy management strategies mitigate uncertainty in renewable generation. (14 marks)

B24EEH73	COMPUTATIONAL ELECTROMAG- NETICS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5		

Preamble

The aim of this course is to introduce analytical and numerical techniques for solving electromagnetic field problems relevant to electrical engineering. This course covers review of electromagnetics, analytical solutions, finite difference and finite element methods, and practical simulation using the software, Finite Element Method Magnetism (FEMM). By the end of the course, students will be able to formulate, discretize, and computationally analyze electromagnetic field problems using modern numerical methods and simulation tools

Prerequisites

ElectroMagnetic field Theory, Electrical Machines

Course Outcomes

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

CO 1	Understand the fundamental principles of electromagnetics to interpret electromagnetic field behavior. (Cognitive Knowledge Level: Understand)
CO 2	Analyze electromagnetic field problems using analytical techniques. (Cognitive Knowledge Level: Apply)
CO 3	Apply finite difference methods to discretize and solve electromagnetic field. (Cognitive Knowledge Level: Apply)
CO 4	Analyze electromagnetic field problems using the finite element method. (Cognitive Knowledge Level: Apply)
CO 5	Apply FEMM software to model and simulate practical electrostatic and magnetostatic 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	3	2	1	2	1	1	1		1		1
CO 2	3	2	2	2	2	2	1	1	1	1	1
CO 3	3	2	3	2	1	2	1		1		1
CO 4	3	2	2	2	1	2	1		1		1
CO 5	3	2	1	2	1	2	1	1	1		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/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)

Fundamental Concepts

Review of electromagnetics - electrostatic fields, magnetostatic fields, time-varying fields, boundary conditions, wave equations, time-varying potentials, classification of EM problems - solution equations, differential equations, boundary conditions, important theorems - superposition principle, uniqueness theorem. Numerical problems.

MODULE 2 (9 hours)

Analytical Methods

Separation of variables - Laplace equations in Cartesian, cylindrical and spherical coordinates, wave equations in Cartesian, cylindrical and spherical coordinates, series expansion - Poisson's equation in a cube, Poisson's equation in a cylinder - practical applications - scattering of dielectric sphere. Numerical problems.

MODULE 3 (9 hours)

Finite Difference Method

Finite difference schemes - finite differencing of parabolic Partial Differential Equations (PDEs), finite differencing of hyperbolic PDEs, finite differencing of elliptic PDEs - band matrix method, accuracy and stability, practical applications, Yee's finite difference algorithm, accuracy and stability, absorbing boundaries for finite difference time domain method. Numerical problems.

MODULE 4 (9 hours)

Finite Element Method

Solution of Laplace equations - finite element discretization, element governing equations, element assembling, equation solving, solution of wave equation, automatic mesh generation-rectangular domain, arbitrary domain, FEM for exterior problems - infinite element method, boundary element method, absorbing boundary condition, finite element time domain method. Numerical problems.

MODULE 5 (9 hours)

FEMM Simulations

Introduction to FEMM - features for electrostatics and magnetostatics problems, geometry,

mesh setup, material libraries, boundary conditions, solvers, electrostatic simulations - implementing Laplace and Poisson equation, practical examples - parallel-plate capacitor with dielectrics, coaxial cables, magnetostatic simulations - magnetostatic problems, applications - solenoid design.

Text Books

1. M. N. O. Sadiku & A. J. Denton, *Numerical Techniques in Electromagnetics with MATLAB*, CRC Press ,3rd ed., 2014.
2. Stanley Humphries Jr, *Finite-Element Methods for Electromagnetics*, Wiley-IEEE Press, 6th ed., 1997
3. J. Jin , *The Finite Element Method in Electromagnetics*, Wiley, 3rd ed., 2014.
4. *Finite Element Method Magnetic*, User Guide: femm.info/Archives/doc/manual.pdf

Reference Books

1. S. M. S. Raju, *Finite Element Method*, Tata McGraw-Hill, 3rd ed., 2005
2. Peter Silvester. Ronald L Ferrari, *Finite Elements for Electrical Engineers*, Cambridge University Press, 3rd ed., 1996
3. Ö. Özgün & M. Kuzuoğlu, *MATLAB-based Finite Element Programming in Electromagnetic Modeling*, CRC Press, 1st ed., 2018.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	45 Hours
	Module 1: Fundamental Concepts	9
1.1	Review of electromagnetics - electrostatic fields, magnetostatic fields	1
1.2	Time-varying fields, boundary conditions	1
1.3	Wave equations, time-varying potentials	1
1.4	Classification of EM problems - solution equations, differential equations	1
1.5	Boundary conditions	2
1.6	Important theorems - superposition principle	1
1.7	Uniqueness theorem	1
1.8	Numerical problems	1
	Module 2: Analytical Methods	9
2.1	Separation of variables - Laplace equations in Cartesian	1
2.2	Laplace equations in cylindrical coordinates	1

2.3	Laplace equations in spherical coordinates	1
2.4	Wave equations in cartesian coordinates	1
2.5	Wave equations in cylindrical coordinates	1
2.6	Wave equations in spherical coordinates	1
2.7	Series expansion - Poisson's equation in a cube	1
2.8	Poisson's equation in a cylinder	1
2.9	Practical applications-scattering of dielectric sphere, numerical problems	1
	Module 3: Finite Difference Method	9
3.1	Finite difference schemes - finite differencing of parabolic Partial Differential Equations (PDEs)	1
3.2	Finite differencing of hyperbolic PDEs	1
3.3	Finite differencing of elliptic PDEs	1
3.4	Band matrix method, accuracy and stability	1
3.5	Practical applications	1
3.6	Yee's finite difference algorithm	1
3.7	Accuracy and stability	1
3.8	Absorbing boundaries for finite difference time domain method	1
3.9	Numerical problems	1
	Module 4: Finite Element Method	9
4.1	Solution of laplace equations - finite element discretization	1
4.2	Element governing equations, element assembling	1
4.3	Equation solving, solution of wave equation	1
4.4	Automatic mesh generation - rectangular domain	1
4.5	Arbitrary domain	1
4.6	FEM for exterior problems - infinite element method	1
4.7	Boundary element method, absorbing boundary condition	1
4.8	Finite element time domain method	1
4.9	Numerical problems	1
	Module 5: FEMM Simulations	9
5.1	Introduction to FEMM - features for electrostatics and magnetostatics problems	1
5.2	Geometry, mesh setup, material libraries, boundary conditions, solvers	1
5.3	Electrostatic simulations- implementing Laplace equation	1
5.4	Implementing Poisson equation	1
5.5	Practical examples - parallel-plate capacitor with dielectrics	2
5.6	Coaxial cables	1
5.7	Magnetostatic simulations - magnetostatic problems	1
5.8	Applications - solenoid design	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Define electrostatic field and magnetostatic field.
2. State Maxwell's equations.
3. What are boundary conditions in EM fields?

Course Outcome 2 (CO 2)

1. Derive the wave equation for electromagnetic fields.
2. Explain boundary conditions at dielectric interfaces.
3. Classify electromagnetic problems with examples.

Course Outcome 3 (CO 3)

1. Explain finite difference scheme for elliptic PDEs.
2. Discuss stability criteria of finite difference methods.
3. Explain Finite Difference Time Domain method.

Course Outcome 4 (CO 4)

1. Explain FEM formulation for Laplace equation.
2. Describe element assembling and equation solving.
3. Explain FEM for exterior problems.

Course Outcome 5 (CO 5)

1. Explain steps in solving EM problems using FEMM.
2. Discuss electrostatic simulation of a parallel plate capacitor.
3. Explain magnetostatic simulation of a solenoid.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: : B24EEH73

Course Name: : COMPUTATIONAL ELECTROMAGNETICS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. State Maxwell's equations.
2. State superposition principle.
3. Define Laplace's equation and Poisson's equation.
4. Write Laplace equation in cylindrical coordinates.
5. Classify PDEs as elliptic, parabolic, and hyperbolic.
6. What is Yee's algorithm?
7. Define element and node.
8. Explain stiffness matrix.
9. Define boundary conditions in FEMM.
10. List the features of FEMM for electrostatics.

PART B

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

11. (a) Derive electromagnetic wave equation from Maxwell's equations. (7 marks)

- (b) Explain the physical significance of the wave equation. (7 marks)

OR

12. (a) Explain time-varying potentials. (7 marks)
(b) Derive governing equations for time-varying potentials. (7 marks)
13. (a) Solve Laplace equation in Cartesian coordinates. (7 marks)
(b) Apply boundary conditions to obtain final solution. (7 marks)

OR

14. (a) Explain scattering of a dielectric sphere. (7 marks)
(b) Discuss its practical applications. (7 marks)
15. (a) Derive finite difference scheme for parabolic PDE. (7 marks)
(b) Discuss stability criteria. (7 marks)

OR

16. (a) Explain Finite Difference Time Domain method. (7 marks)
(b) Discuss the importance of absorbing boundary conditions in FDTD. (7 marks)
17. (a) Explain finite element time domain method. (7 marks)
(b) Explain boundary element method. (7 marks)

OR

18. (a) Derive the finite element formulation for solving Laplace's equation. (7 marks)
(b) Assemble the global stiffness matrix and apply boundary conditions for a simple problem. (7 marks)
19. (a) Explain the workflow of solving an electromagnetic problem using FEMM. (7 marks)
(b) Discuss advantages and limitations of FEMM. (7 marks)

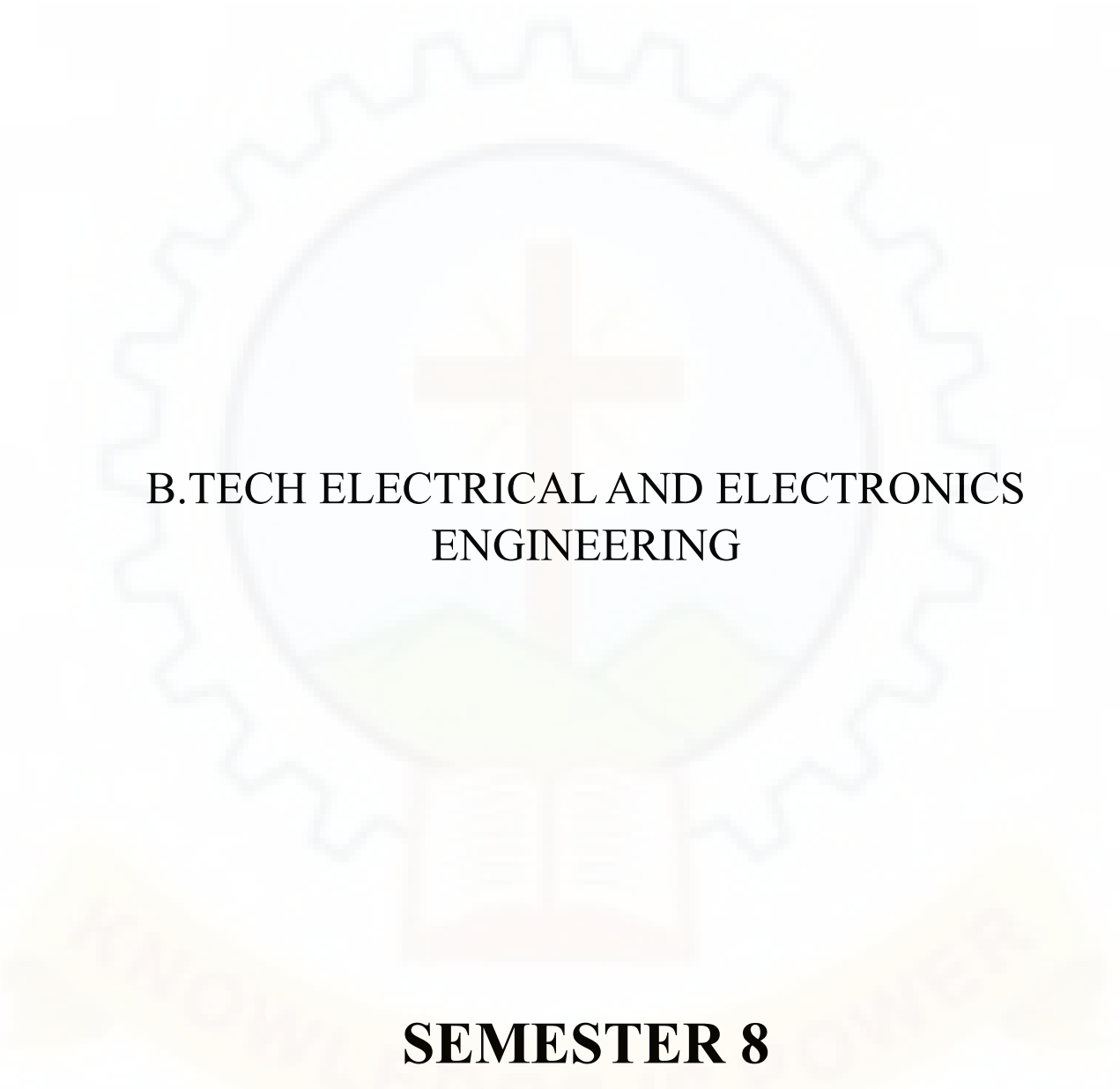
OR

20. (a) Explain the procedure to simulate a coaxial cable in FEMM. (7 marks)
(b) Explain magnetostatic problem formulation in FEMM. (7 marks)

MAR ATHANASIOUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution

Kothamangalam, Kerala, India



B.TECH ELECTRICAL AND ELECTRONICS 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	B24EE4P5X	PROGRAMME ELECTIVE V	2-1-0-4	3	3
B	B24EE4P6X	PROGRAMME ELECTIVE VI	2-1-0-4	3	3
C	B24EE4G3X	OPEN ELECTIVE III	2-1-0-4	3	3
AND					
H	B24EE4L14	PROJECT PHASE II	0-0-12-3	12	6
M	B24EEML1	MINOR PROJECT	0-0-3-12	3	6
N	B24EEHL1	HONOURS PROJECT	0-0-6-9	6	6
TOTAL*				30	15

PROGRAMME ELECTIVE V

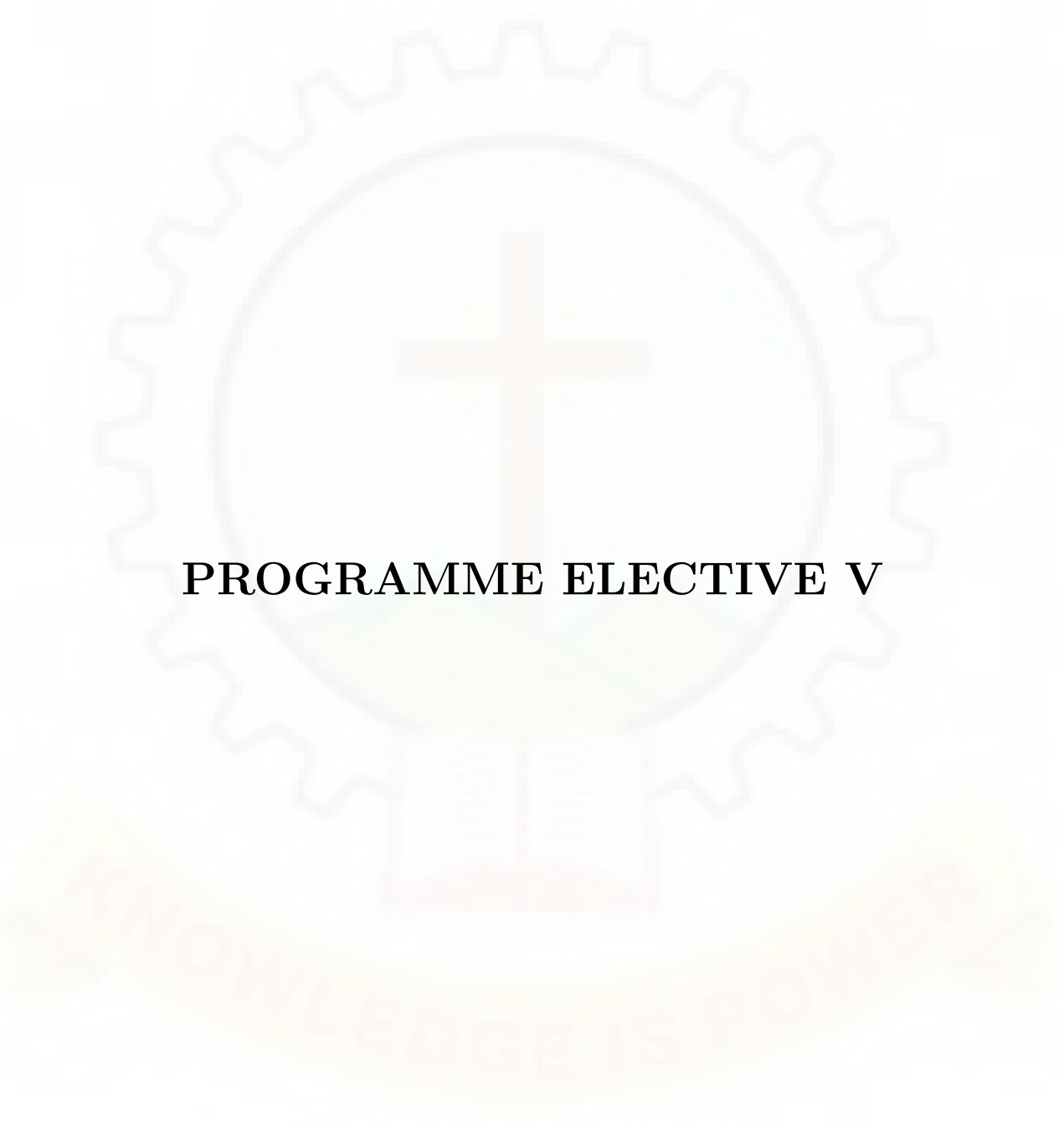
COURSE NO.	COURSES
B24EE4P51	NON-LINEAR CONTROL THEORY
B24EE4P52	ADVANCED ELECTRIC DRIVES
B24EE4P53	POWER SYSTEMS OPERATION AND CONTROL
B24EE4P54	CMOS ANALOG CIRCUIT DESIGN
B24EE4P55	NANOELECTRONICS
B24EE4P56	DEEP LEARNING

PROGRAMME ELECTIVE VI

COURSE NO.	COURSES
B24EE4P61	PROCESS CONTROL AND INSTRUMENTATION
B24EE4P62	POWER CONVERTERS FOR POWER SYSTEM APPLICATIONS
B24EE4P63	SMART GRID TECHNOLOGIES
B24EE4P64	REAL-TIME OPERATING SYSTEMS
B24EE4P65	MICROELECTROMECHANICAL SYSTEMS
B24EE4P66	SOFT COMPUTING TECHNIQUES

OPEN ELECTIVE III

COURSE NO.	COURSES
B24EE4G31	INDUSTRIAL INSTRUMENTATION
B24EE4G32	SUSTAINABLE ENERGY SYSTEMS
B24EE4G33	HUMAN FACTORS ENGINEERING
B24EE4G34	ELECTRICITY MARKETS
B24EE4G35	INTERNET OF THINGS
B24EE4G36	SMART GRID ENGINEERING



PROGRAMME ELECTIVE V

B24EE4P51	NON-LINEAR CONTROL THEORY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course provides a comprehensive understanding of non-linear dynamical systems and the analytical methods used to study their behavior in engineering applications. It focuses on stability and robustness analysis of non-linear systems using time-domain and frequency-domain techniques. The course also develops the ability to design effective non-linear control strategies that ensure desired system performance and stability.

Prerequisites

Advanced Control Systems

Course Outcomes

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

CO 1	Analyze the qualitative behavior of nonlinear dynamical systems using classical analytical approach. (Cognitive Knowledge Level: Apply)
CO 2	Analyze the stability characteristics of nonlinear systems using state space based theoretical methods. (Cognitive Knowledge Level: Apply)
CO 3	Evaluate the robustness and stability of nonlinear systems under external inputs and interconnections.(Cognitive Knowledge Level: Apply)
CO 4	Analyze nonlinear feedback systems from time domain and frequency domain perspectives. (Cognitive Knowledge Level: Apply)
CO 5	Design controllers for nonlinear systems using advanced methods. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	2	1							1
CO 2	3	2	2	1	1						1
CO 3	3	2	2	1	1						1
CO 4	3	2	2	1							1
CO 5	3	2	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	20	20	20
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 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)

Introduction to Non-linear System Analysis

Qualitative behaviour of linear systems - vector field representation, classification of equilibrium points, qualitative behaviour near equilibrium points, limit cycles, existence of periodic orbits - Bendixon theorem, Poincare-Bendixon criterion, analysis of systems with piecewise constant inputs using phase plane analysis.

MODULE 2 (7 hours)

Lyapunov Stability

Existence and uniqueness of solutions of non-linear state equations, stability of non-linear systems - Lyapunov stability, local linearization and stability in the small, centre manifold theorem, direct method of Lyapunov, generation of Lyapunov function for linear and non-linear systems, variable gradient method, La Salle's invariance theorem.

MODULE 3 (7 hours)

Frequency Domain Analysis of Feedback Systems

Absolute stability of feedback interconnections of a linear part and nonlinear part, circle criterion, Popov criterion, analysis through harmonic linearization, describing function of combinational non-linearities, amplitude and frequency of limit cycle using sinusoidal input describing function.

MODULE 4 (6 hours)

Feedback Linearization

Control problems, stabilization via linearization, integral control via linearization, gain scheduling. Feedback linearization, state feedback control, stabilization, and tracking via state feedback control.

MODULE 5 (7 hours)

Nonlinear System Design Tools

Sliding mode control - regulation via integral control, Lyapunov redesign - stabilization and non-linear damping, backstepping.

Text Books

1. Hassan K Khalil, *Nonlinear Systems*, Prentice - Hall International (UK), 3rd ed., 2015.
2. Alberto Isidori, *Nonlinear Control Systems: An Introduction*, Springer-Verlag, 2nd ed., 1989
3. Jean-Jacques E. Slotine and Weiping Li, *Applied Nonlinear Control*, Prentice-Hall, NJ, 1st ed., 1991.

Reference Books

1. M. Vidyasagar, *Nonlinear Systems Analysis*, Prentice-Hall, India, 2nd ed., 1993
2. Shankar Sastry, *Nonlinear System Analysis, Stability and Control*, Springer, 1st ed., 1999.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Non-linear System Analysis	9
1.1	Qualitative behaviour of linear systems	1
1.2	Vector field representation	2
1.3	Classification of equilibrium points	2
1.4	Qualitative behaviour near equilibrium points	1
1.5	Limit cycles, existence of periodic orbits - Bendixon theorem	1
1.6	Poincare-Bendixon criterion, analysis of systems with piecewise constant inputs using phase plane analysis	1
1.7	Analysis of systems with piecewise constant inputs using phase plane analysis	1
	Module 2: Lyapunov Stability	7
2.1	Existence and uniqueness of solutions of non-linear state equations	1
2.2	Ability of non-linear systems - Lyapunov stability	2
2.3	Bilinear transformation	1
2.4	Local linearization and stability in the small, centre manifold theorem	1
2.5	Direct method of Lyapunov, generation of Lyapunov function for linear and non-linear systems	1
2.6	Variable gradient method, La Salle's invariance theorem	1
	Module 3: Frequency Domain Analysis of Feedback Systems	7

3.1	Absolute stability of feedback interconnections of a linear part and non-linear part	2
3.2	Circle criterion, Popov criterion	1
3.3	Analysis through harmonic linearization	1
3.4	Describing function of combinational non-linearities	2
3.5	Amplitude and frequency of limit cycle using sinusoidal input describing function	1
	Module 4: Feedback Linearization	6
4.1	Control problems, stabilization via linearization	2
4.2	Integral control via linearization	1
4.3	Gain scheduling	1
4.4	Feedback linearization	1
4.5	State feedback control - stabilization and tracking via state feedback control	1
	Module 5: Non-linear System Design Tools	7
5.1	Sliding mode control	2
5.2	Regulation via integral control	1
5.3	Lyapunov redesign - stabilization and non-linear damping	2
5.4	Backstepping	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Determine the type and stability of equilibrium points for a non-linear system.
2. Construct the vector field of a given system and interpret the system trajectories.
3. Analyze the existence of limit cycles using the Poincaré–Bendixson criterion.

Course Outcome 2 (CO 2)

1. Apply LaSalle's invariance theorem to analyze system stability.
2. Use the variable gradient method to generate a Lyapunov function.
3. Analyze the stability of non-linear systems using the centre manifold theorem.

Course Outcome 3 (CO 3)

1. Analyze the absolute stability of a non-linear feedback system using the circle criterion.
2. Apply the Popov criterion to determine stability of a non-linear system.

3. Evaluate system behavior using describing function analysis.

Course Outcome 4 (CO 4)

1. Design a controller using feedback linearization for a non-linear system.
2. Apply state feedback control for stabilization of non-linear systems.
3. Analyze tracking performance using state feedback control.

Course Outcome 5 (CO 5)

1. Design a sliding mode controller for a non-linear system.
2. Apply Lyapunov redesign for stabilization of non-linear systems.
3. Design a controller using backstepping technique.

MODEL QUESTION PAPER

QP CODE:

Pages: 4

Reg.No.:

Name:

MAR ATHANASIOUS COLLEGE OF ENGINEERING (AUTONOMOUS),
KOTHAMANGALAM

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2028

Course Code: : B24EE4P51

Course Name: : NON-LINEAR CONTROL THEORY

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What distinguishes a stable node from an unstable node? Draw typical phase portraits to illustrate the difference.
2. State the conditions to be satisfied in Poincare-Bendixson criterion, for a closed bounded subset of phase plane to contain a limit cycle.
3. What is invariant set? How is La Salle's invariance theorem useful in stability analysis in non-linear systems?
4. Check the sign definiteness of the quadratic function described by $V(x) = 2x_1^2 + 3x_2^2 + x_3^2 + 4x_1x_3 + 6x_2x_3$
5. What is the significance of Popov criterion? Mention Popov criterion.
6. Derive the describing function of the on-off nonlinearity.
7. Write a brief note on integral control. Also, mention an advantage of the integral control scheme.
8. What is feedback linearization? Mention its fundamental principles.
9. State the basic idea of Lyapunov redesign for robust stabilization of a non-linear system in the presence of uncertainty.
10. Briefly explain the recursive structure of backstepping in stabilizing strict feedback non-linear systems.

PART B

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

11. (a) Find and classify all equilibrium points for the system (7 marks)

$$\dot{x}_1 = -x_1 + x_1x_2$$

$$\dot{x}_2 = x_1 + x_2 - 2x_1x_2$$

- (b) Construct the phase portrait for the system (7 marks)

$$\ddot{x} + \dot{x} + |x| = 0$$

Mention the inferences.

OR

12. (a) Identify the non-linear phenomenon evident in the given non-linear system equation. (5 marks)

$$\ddot{x} + \alpha x + x^3 = 0$$

Elaborate on its important features.

- (b) Consider the system given by (9 marks)

$$\dot{x}_1 = (u - x_1)(1 + x_2^2)$$

$$\dot{x}_2 = x_1 - 2x_2(1 + x_1^2)$$

$$y = x_2$$

The system is controlled by output feedback $u = -Ky$. Determine

- The equilibrium points of the closed loop system for all values of gain K .
 - The nature of equilibrium point (origin) for all values of gain K .
13. (a) Apply Lyapunov's indirect method and determine the stability about the origin for $\dot{x}_1 = ax_1$, $\dot{x}_2 = -\sin x_1 - bx_2$, when constants i) $b, a > 0$, ii) $b < 0$, $a < 0$, iii) $b = 0$, $a = 0$. (7 marks)
- (b) Explain in detail any one method to generate a Lyapunov function to prove the stability of the non-linear system. (7 marks)

OR

14. (a) A simple pendulum is described by

$$ml\ddot{\theta} = -mg \sin \theta - kl\dot{\theta}$$

where l denotes length of the rod, m denotes mass of the bob, θ being the angle subtended by the rod and vertical axis through the pivot, k is coefficient of friction and g is acceleration due to gravity. Prove using LaSalle's invariance principle that the system is asymptotically stable in a domain by choosing the Lyapunov function as the total energy function. (10 marks)

- (b) Show that the system

$$\dot{x}_1 = -x_2 - x_1(1 - x_1^2 - x_2^2)$$

$$\dot{x}_2 = x_1 - x_2(1 - x_1^2 - x_2^2)$$

is asymptotically stable by choosing a quadratic Lyapunov function. (4 marks)

15. (a) Differentiate between the conditions required for absolute stability of an interconnected feedback system with sector non-linearity in the feedback path whose bounds are (a) $[K_1, \infty)$ (b) $[K_1, K_2]$. (6 marks)

- (b) The forward path transfer function of a feedback interconnected system with sector non-linearity in feedback path is given by

$$G(s) = \frac{1}{s^2 + 5s + 6}.$$

Apply Popov criterion to find the sector for absolute stability. (8 marks)

OR

16. (a) Using circle criteria, for the system $G(s) = \frac{1-s}{s^2+2s+1}$,
i. Find a sector $[\alpha, \beta]$ (where $\beta > 0$) so that α is not equal to zero to which the non-linearity, $\Psi(\cdot)$ should be confined so that the whole system is absolutely stable. The Nyquist plot of $G(s)$ is as shown.

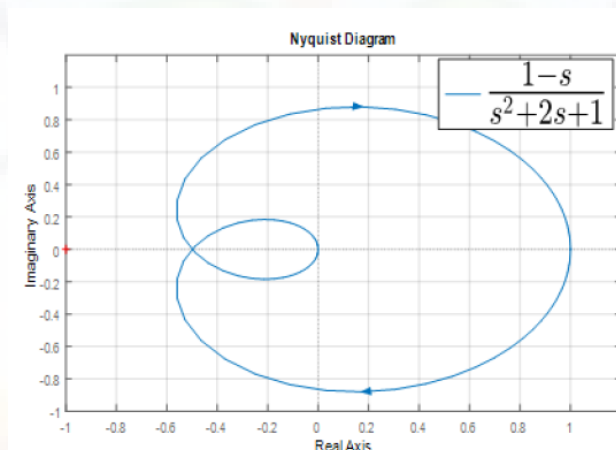


Figure 1: Caption

- ii. Can we find a sector $[\alpha, \beta]$ with $\alpha = 0$ so that the system is absolutely stable? (7 marks)
- (b) State and explain the Popov's stability criterion (scalar case) to prove absolute stability. (7 marks)
17. (a) Explain the concept of gain scheduling based control for a non-linear system with an example. (4 marks)

- (b) Design a stabilising integral controller to regulate the angle θ to θ_r for the system described by

$$\ddot{\theta} = -a \sin \theta - b\dot{\theta} + cT,$$

where $a, b, c > 0$ and T is the torque applied. (10 marks)

OR

18. Check if it is possible to full state linearise the system described by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = f(x) + gu$$

where, $f(x) = \begin{bmatrix} a \sin x_2 \\ -x_1^2 \end{bmatrix}$, $g = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$. If so why? If so, then systematically obtain an $h(x) = y$ and a control law that will help in full state linearization and asymptotically stabilisation of the system. (14 marks)

19. Consider the system:

$$\dot{\eta} = \eta^2 - \eta^3 + \xi, \quad \dot{\xi} = u$$

- (a) Design a backstepping control law u to stabilize the origin of the system.
(b) Write down the associated Lyapunov function V and its time derivative $\dot{V}$.
(c) Evaluate u , V and $\dot{V}$, when $\eta(5) = 2$ and $\xi(5) = 6$. (14 marks)

OR

20. Explain with an example the backstepping control technique for a strict-feedback non-linear system. (14 marks)

B24EE4P52	ADVANCED ELECTRIC DRIVES	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The aim of this course is to provide students with a comprehensive understanding of modern electric drive systems used in industrial, automation, and traction applications. The course covers advanced induction motor drives, stepper motor drives, brushless DC and PMSM drives, and switched reluctance motor drives, with emphasis on power electronic control and performance characteristics. Upon completion of the course, students will be able to analyze and select appropriate electric drive systems and control strategies for various practical and industrial applications.

Prerequisites

Power Electronics

Course Outcomes

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

CO 1	Understand the fundamental concepts of electric drive systems and their role in energy conservation. (Cognitive Knowledge Level: Understand)
CO 2	Analyze induction motor drive control techniques for variable-speed applications. (Cognitive Knowledge Level: Apply)
CO 3	Apply knowledge of stepper motor principles, and control strategies that enable precise position and motion control, with an emphasis on sustainable engineering practices. (Cognitive Knowledge Level: Apply)
CO 4	Analyse the performance characteristics of BLDC and PMSM drive systems with a focus on energy efficiency and reduced environmental impact. (Cognitive Knowledge Level: Apply)
CO 5	Analyze the construction, operating principles, torque production, of switched reluctance motor drive systems. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	1	1	1	1	1	2				3
CO 2	3	2	2	1	1	1	2				3
CO 3	3	2	2	1	1	2	2				3
CO 4	3	2	2	1	1	2	2			2	3
CO 5	3	2	2	1	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	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 (7 hours)

Electric Drive System

Electric Drives - block diagram, advantages, limitations, components, torque equation, multi-quadrant operation, types of load torque, need for variable speed drives - applications, review of speed control techniques in DC and AC drives, role of electric drives in energy conservation - regeneration, field weakening operations.

MODULE 2 (7 hours)

Induction Motor Drives

Three phase induction motor - steady state equations, equivalent circuit, V/f control - VSI, CSI fed drive, principle of vector control - comparison with SEDC, rotating magnetic field, space-vector theory, 3 phase-2 phase transformation - MMF equivalence, power equivalence, reference frame theory, indirect field oriented control (FOC), direct FOC, direct torque control (DTC).

MODULE 3 (7 hours)

Stepper Motor Drives

Elementary stepper motors - principle of operation, types - variable reluctance, permanent magnet and hybrid motors, torque production, stepping rate characteristics, pull-in and pull-out characteristics, unipolar and bipolar drive schemes, bifilar drives, open loop position control.

MODULE 4 (8 hours)

Permanent Magnet Motor Drives

PMSM - constructional features, permanent magnet rotor types - surface mounted, surface-inset, interior PMSMs, torque equation, principle of operation, sinusoidal MMF distribution, vector control, field weakening. BLDC - constructional features, speed-torque characteristics, electronic commutation using hall-effect sensors, control strategies for BLDC motors - six-step commutation, PWM control, applications of BLDC drives.

MODULE 5 (7 hours)

Switched Reluctance Motor (SRM) Drives

Evolution and topologies of SRM systems, comparison with other motor drives, principle of operation, control requirements, converter circuits for SRM, modes of operation, commutation angle generation, multi-phase SRM.

Text Books

1. G. K. Dubey, *Power Semiconductor Controlled Drives*, Prentice Hall, 2nd ed., 2000.
2. G. K. Dubey, *Fundamentals of Electrical Drives*, Narosa Publishers, 2nd ed., 2002.
3. Bimal K. Bose, *Modern Power Electronics and AC Drives*, Prentice Hall of India, 1st ed., 2024(Reprint).
4. Paul Acarnley, *Stepping Motors: A Guide to Theory and Practice*, IET, UK, 4th ed., 2002.
5. R. Krishnan, *Permanent Magnet Synchronous and Brushless DC Drives*, CRC Press, 2nd ed. 2010.
6. T. J. E. Miller, *Switched Reluctance Motor and Their Control*, Clarendon Press, Oxford, 2nd ed., 2008.

Reference Books

1. W. Shepherd, L. N. Hulley, and D. T. W. Liang, *Power Electronics and Motor Control*, Cambridge University Press, 2nd ed., 2004
2. Werner Leonhard, *Control of Electrical Drives*, Springer, 3rd ed., 2007.
3. P. C. Krause, O. Wasynczuk, and S. D. Sudhoff, *Analysis of Electric Machinery and Drive Systems*, IEEE Press, 2nd ed., 2002.
4. Eltamaly, A. M., Alolah, *Electric Motor Drives: Concepts and Applications*, Springer, 2020.
5. Ion Boldea, *Electrical Drives*, CRC Press, 3rd ed., 2016.
6. Rashid, M. H., *Power Electronics: Circuits, Devices and Applications*, Pearson Education, 4th ed., 2019.
7. Krishnan, R., *Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, and Applications*, CRC Press, 4th ed., 2017.
8. Dinolova, P.; Ruseva, V.; Dinolov, O., *Energy Efficiency of Induction Motor Drives: State of the Art, Analysis and Recommendations*, Energies 2023.
<https://doi.org/10.3390/en16207136>

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Electric Drive System	7
1.1	Electric Drives - block diagram, advantages, limitations, components	1
1.2	Torque equation	1
1.3	Multi-quadrant operation, types of load torque	1
1.4	Need for variable speed drives - applications, review of speed control techniques in DC Drives	1
1.5	Review of speed control techniques in AC drives	1
1.6	Role of electric drives in energy conservation - regeneration, field weakening operations	2
	Module 2: Induction Motor Drives	7
2.1	Three phase induction motor - steady state equations	1
2.2	Equivalent circuit, V/f control - VSI, CSI fed drive	1
2.3	Principle of vector control - comparison with SEDC, rotating magnetic field	1
2.4	Space-vector theory, 3 phase-2 phase transformation - MMF equivalence, power equivalence	2
2.5	Reference frame theory, indirect field oriented control (FOC), direct FOC, direct torque control (DTC)	2
	Module 3: Stepper Motor Drives	7
3.1	Elementary stepper motors - principle of operation	1
3.2	Types - variable reluctance, permanent magnet and hybrid motors	2
3.3	Torque production, stepping rate characteristics, pull-in and pull-out characteristics-numerical problems	2
3.4	Unipolar and bipolar drive schemes	1
3.5	Bifilar drives, open loop position control	1
	Module 4: Permanent Magnet Motor Drives	8
4.1	PMSM - constructional features, permanent magnet rotor types - surface mounted, surface-inset, interior PMSMs	2
4.2	Torque equation, principle of operation	1
4.3	Sinusoidal MMF distribution, vector control, field weakening	1
4.4	BLDC- constructional features, speed-torque characteristics	1
4.5	Electronic commutation using hall-effect sensors	1
4.6	Control strategies for BLDC motors - six-step commutation, PWM control, applications of BLDC Drives	2

	Module 5: Switched Reluctance Motor (SRM) Drives	7
5.1	Evolution and topologies of SRM systems	1
5.2	Comparison with other motor drives, principle of operation	1
5.3	Control requirements, converter circuits for SRM	2
5.4	Modes of operation, commutation angle generation	2
5.5	Multi-phase SRM	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the basic components of an electric drive system and describe their functions.
2. Discuss the role of electric drive systems in energy conservation with suitable examples.
3. Illustrate the concept of load characteristics and their impact on the selection of electric drives.

Course Outcome 2 (CO 2)

1. Explain and evaluate different speed control methods of induction motor drives such as V/f control and vector control.
2. Analyze the performance of an induction motor under variable frequency control for different load conditions.
3. Apply appropriate control techniques to achieve efficient variable-speed operation in induction motor drives.

Course Outcome 3 (CO 3)

1. Explain the operating principles and characteristics of stepper motors used in drive systems.
2. Analyze open-loop control strategies in stepper motors for achieving precise position control.
3. Apply stepper motor drive schemes to design a simple motion control system for positioning applications.

Course Outcome 4 (CO 4)

1. Compare BLDC and PMSM drive systems based on construction, operation, and applications.
2. Analyze the speed-torque characteristics of BLDC and PMSM motors under different operating conditions.
3. Evaluate control techniques used in BLDC and PMSM drives for efficient performance.

Course Outcome 5 (CO 5)

1. Explain the construction and operating principles of switched reluctance motor drives.
2. Analyze the torque production mechanism in SRM drives with suitable diagrams.
3. Evaluate the performance characteristics of SRM drives and discuss their advantages and limitations.

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: : B24EE4P52

Course Name: : ADVANCED ELECTRIC DRIVES

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. List any three advantages of electric drives over mechanical drives.
2. Explain the concept of multi-quadrant operation in electric drives with suitable examples.
3. Why is V/f control widely used in variable speed drives?
4. Draw the equivalent circuit of a three phase induction motor and briefly describe the significance of each element.
5. Explain the pull-in and pull-out characteristics of a stepper motor.
6. Differentiate between unipolar and bipolar drive schemes used in stepper motors.
7. Explain the role of Hall-effect sensors in electronic commutation.
8. What is the function of the stator in a PMSM?
9. List any three advantages of SRM drives compared to conventional motor drives.
10. Explain the importance of commutation angle generation in a four phase SRM system.

PART B

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

11. (a) Discuss the need for variable speed drives in industrial applications. Explain with at least three practical examples. (7marks)
- (b) Explain the torque equation of an electric drive system and analyze how load torque affects the performance of the drive. (7 marks)

OR

12. Explain the role of electric drives in energy conservation with special reference to regeneration and field weakening operations. (14 marks)
13. Compare the principle of vector control of induction motors with the speed control of separately excited DC motors (SEDC). Highlight similarities and differences in terms of torque and flux control. (14 marks)

OR

14. Discuss the reference frame theory and its role in indirect field oriented control (IFOC) and direct field oriented control (FOC). How does it simplify the analysis and control of three phase induction motors? (14 marks)
15. (a) Explain the principle of torque production in a variable reluctance stepper motor. (7 marks)
- (b) Explain the working of open loop position control using stepper motors. Highlight its advantages, limitations, and typical applications in automation systems. (7 marks)

OR

16. (a) Explain the working of a bifilar drive for a stepper motor and discuss how it improves motor control. (7 marks)
- (b) Explain the construction and working principle of a Permanent Magnet (PM) stepper motor. Compare it with a Variable Reluctance stepper motor. (7 marks)
17. Derive the torque equation of a PMSM and describe how sinusoidal MMF distribution with distributed windings contributes to smooth torque production. (14 marks)

OR

18. A Brushless DC (BLDC) motor is used in an electric vehicle drive system. Draw and explain the electronic commutation process using Hall-effect sensors for this application. Analyze the speed-torque characteristics of the BLDC motor and explain how six-step commutation combined with PWM control can be applied to regulate performance under varying load conditions. Suggest two practical applications of BLDC drives in modern industry and justify their suitability. (14 marks)

19. (a) Explain the converter circuits used for SRM drives. How do they meet the control requirements for different modes of operation? Illustrate with suitable diagrams. (7 marks)
- (b) Compare the topologies of SRM systems with other motor drives. Discuss their advantages and limitations in terms of construction, efficiency, and control requirements. (7marks)

OR

20. Explain the principle of operation of a Switched Reluctance Motor. Also describe the control requirements of SRM drives . (14 marks)

B24EE4P53	POWER SYSTEM OPERATION AND CONTROL	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4		

Preamble

This course aims to enable the students with an understanding of the basic concepts of electrical power system, electricity markets and its operations and control. The course provides an overview of various operations, control techniques and scheduling problems for stable and economic load dispatch along with the basic concepts of electricity markets and trading. The course equips the students to understand and analyse various control and trading strategies for the efficient operation of electrical power systems.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand and analyse the characteristics for the economic operation and control of power system. (Cognitive Knowledge Level: Understand)
CO 2	Understand and apply the scheduling of hydrothermal power plants along with the basic concepts of load forecasting and dispatching. (Cognitive Knowledge Level: Apply)
CO 3	Apply load compensation and various reactive power control strategies for power system stability. (Cognitive Knowledge Level: Apply)
CO 4	Understand and apply the concepts of economic interchange of power and energy between interconnected utilities and various aspects of power system security. (Cognitive Knowledge Level: Understand)
CO 5	Understand and apply the concepts of Energy markets and trading. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1		1	2	1	1	1	2	2
CO 2	3	2	1		1	2	1	1	1	1	2
CO 3	3	2	1		1	2	1	1	1		2
CO 4	3	1				2	1	1	1		2
CO 5	3	1				2	1	1	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	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/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)

Economic Operation and Control of Power System

Economic operation of power systems, characteristics of power generation unit, input-output characteristics, cost curve, incremental fuel cost curve, heat rate curve, incremental efficiency. Need for Power system control, hierarchical control structure, advantages of computer control, classification of operating problems in power systems.

MODULE 2 (7 hours)

Hydrothermal Scheduling

Hydroelectric power plant models, scheduling problems, short-term hydrothermal scheduling problem - gradient approach, hydro units in series, pumped storage hydro plants, dynamic programming solution to hydrothermal scheduling problem. Basic concepts of load dispatching, load forecasting, load shedding, and islanding.

MODULE 3 (8 hours)

Load Compensation

Load compensation - objectives, specifications, characteristic impedance of compensated transmission lines, shunt compensators, series compensators.

Reactive Power - Voltage Control

Necessity of voltage control, generation and absorption of reactive power, location of voltage control equipment, basics of reactive power control - Automatic Voltage Regulator (AVR), methods of voltage control - excitation control, shunt capacitors and reactors, series capacitors, tap changing transformers, booster transformers, synchronous condensers, SVC-TCR, TSC, STATCOM.

MODULE 4 (6 hours)

Interchange of Energy and Power System Security

Economy interchange between interconnected utilities, inter-utility economy energy evaluation, capacity interchange, diversity interchange, energy banking, emergency power interchange, inadvertent power exchange, power pools, transmission effects and issues. Introduction to power system security - factors affecting power system security.

MODULE 5 (8 hours)

Introduction to Energy Markets and Trading

Electricity as a commodity - concepts, trading periods, forward markets – bilateral or decentralized trading, centralized trading - principles of centralized trading, day ahead centralized trading, market clearing price, recovering the fixed cost, comparison of decentralized and centralized trading, spot markets - operation of spot markets, interaction between spot market and forward market, forward contracts and forward markets, future contracts and future markets, options, contracts for difference, managing the price risks, market efficiency.

Text Books

1. J. Wood and B. F. Wollenberg, *Power Generation, Operation and Control*, John Wiley and Sons, 3rd ed., New york 2013.
2. S. Sivanagaraju, G. Sreenivasan, *Power System Operation and Control*, Pearson Publication, 1st ed., 2010.
3. Abhijit Chakrabarti and Sunita Halder, *Power System analysis Operation and Control*, PHI learning private limited, 3rd ed., 2011.
4. Daniel S. Kirschen and Goran Strbac, *Fundamentals of Power System Economics*, Wiley, 2nd ed., 2018.

Reference Books

1. P. Kundur, *Power System Stability and Control*, McGraw Hill, 1st ed., New York, 1994.
2. A. Chakrabarti, D. P. Kothari, A. K. Mukhopadhyay and Abhinandan De, *Introduction to Reactive Power Control and Voltage Stability in Power Transmission Systems*, Prentice Hall India Pvt.limited, 1st ed., 2010.
3. Steven Stoft, *Power System Economics: Designing Markets for Electricity*, Wiley-IEEE Press, 1st ed., 2002.
4. Mohammad Shahidehpour and Muwaffaq Alomoush, *Restructured Electrical Power Systems: Operation: Trading, and Volatility*, Marcel Dekker Inc., 1st ed., 2001.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Economic Operation and Control of Power System	7
1.1	Economic operation of power systems, characteristics of power generation unit, input-output characteristics	1
1.2	Cost curve, incremental fuel cost curve, heat rate curve, incremental efficiency - Numerical problems	2
1.3	Numerical problems	1
1.4	Need for Power system control, hierarchical control structure	1
1.5	Advantages of computer control, classification of operating problems in power systems.	2
	Module 2: Hydrothermal Scheduling	7
2.1	Hydroelectric power plant models, scheduling problems	1
2.2	Short-term hydrothermal scheduling problem - gradient approach.	2
2.3	Hydro units in series, pumped storage hydro plants, dynamic programming solution to hydrothermal scheduling problem - Numerical problems	2
2.4	Basic concepts of load dispatching, load forecasting, load shedding, and islanding.	2
	Module 3: Load Compensation and Reactive Power - Voltage Control	8
3.1	Load compensation - objectives, specifications	1
3.2	Characteristic impedance of compensated transmission lines, shunt compensators, series compensators.	2
3.3	Necessity of voltage control, generation and absorption of reactive power, location of voltage control equipment	2
3.4	Basics of reactive power control - Automatic Voltage Regulator (AVR), methods of voltage control - excitation control, shunt capacitors and reactors, series capacitors, tap changing transformers, booster transformers, synchronous condensers, SVC-TCR,TSC, STATCOM.	1
3.5	Tap changing transformers, booster transformers, synchronous condensers, SVC-TCR,TSC, STATCOM	2
	Module 4: Interchange of Energy and Power System Security	6
4.1	Economy interchange between interconnected utilities	1
4.2	Inter-utility economy energy evaluation, capacity interchange, diversity interchange,	2

4.3	Energy banking, emergency power inter-change, inadvertent power exchange, power pools, transmission effects and issues	2
4.4	Introduction to power system security - factors affecting power system security.	1
	Module 5: Introduction to Energy Markets and Trading	8
5.1	Electricity as a commodity - concepts, trading periods, forward markets	1
5.2	Bilateral or decentralized trading, centralized trading - principles of centralized trading, day ahead centralized trading, market clearing price, recovering the fixed cost	3
5.3	Comparison of decentralized and centralized trading, spot markets - operation of spot markets, interaction between spot market and forward market	2
5.4	Forward contracts and forward markets, future contracts and future markets, options, contracts for difference, managing the price risks, market efficiency	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain Heat rate curve.
2. Discuss on the need of power system control.
3. Explain the advantages of computer control in a power system.

Course Outcome 2 (CO 2)

1. Explain the Gradient approach in Short Term Hydrothermal scheduling.
2. Discuss on pumped storage hydro plants.
3. Define the terms Load forecasting and Load shedding.

Course Outcome 3 (CO 3)

1. Explain how load compensation enhances power transfer.
2. Describe the relation between Voltage and Reactive power.
3. Discuss the significance of STATCOM.

Course Outcome 4 (CO 4)

1. Explain the concept of capacity interchange between inter connected utilities.
2. Distinguish between Energy banking and Power pools.
3. Describe the need for power system security.

Course Outcome 5 (CO 5)

1. Explain the concept of Electricity markets and trading.
2. Discuss on Decentralised trading.
3. Explain future contracts and future markets.

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: : B24EE4P53

Course Name: : POWER SYSTEMS OPERATION AND CONTROL

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain incremental fuel cost curve.
2. Describe the input-output characteristic of a power generation unit.
3. Explain the use of Pumped storage hydro plant [PSHP].
4. Explain Load shedding and islanding.
5. Discuss the objectives of load compensation.
6. What is meant by compensated transmission lines.
7. Distinguish between capacity interchange and diversity interchange.
8. Explain Economy Interchange between two interconnected utility areas.
9. Compare decentralized and centralized trading.
10. Define Spot market and forward market.

PART B

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

11. The heat rate of a 100 MW unit is given by the expression:

$$H = 10^6(0.05P^2 + 15P + 180) \text{ kcal/hr}$$

The fuel used has a calorific value of 6000 kcal/kg and costs Rs 2500 per ton.

- (a) Derive the Fuel Cost Curve $C(P)$ in terms of Rs/ hr. Also Find the Incremental Fuel Cost (IFC) equation and calculate the IFC when the unit is delivering 60 MW. (9 marks)
- (b) Calculate the thermal efficiency of the unit at 50 MW and 100 MW. Based on these results, plot a rough sketch of the Heat Rate Curve vs Output and explain why it is usually "U-shaped" or non-linear. (5 marks)

OR

12. Two generating units have fuel cost functions $F_1(P_1)$ and $F_2(P_2)$. The incremental fuel costs are $IFC_1 = 0.01P_1 + 25$ and $IFC_2 = 0.015P_2 + 20$ (Rs/MWh). The total load to be met is $P_D = 500$ MW. Determine the optimal schedule (P_1, P_2) and the resulting savings in total hourly fuel cost if the load is dispatched economically, compared to an equal sharing of the load. (14 marks)
13. A pumped storage plant has a generating capacity of 200 MW and a pumping capacity of 220 MW. The efficiency of the pumping-generating cycle is 75%. It is used to level the load of a thermal system. The thermal plant incremental cost is:

$$\frac{dC}{dP_{gt}} = 0.1P_{gt} + 40 \text{ Rs/MWh}$$

- (a) Explain the operational logic of a pumped storage plant. Under what condition of incremental cost (λ) is it economically feasible to switch from pumping to generating. (5 marks)
- (b) During off-peak hours, the thermal load is 100 MW. During peak hours, the thermal load is 400 MW. Calculate the cost savings achieved by using the pumped storage plant for 4 hours of pumping and 4 hours of generating. (9 marks)

OR

14. Define Load Forecasting and classify it based on the forecasting horizon (Short-Term, Medium-Term, Long-Term). Explain why accurate Short-Term Load Forecasting (STLF) is essential for the effective operation of an Economic Load Dispatch (ELD) and a Hydrothermal Scheduling program. List two key factors that significantly influence STLF accuracy. (14 marks)
15. (a) Explain how series compensation fundamentally differs from shunt compensation and specify which type primarily addresses the reduction of line reactance. (6 marks)

- (b) Define the terms Voltage Stability and Voltage Collapse. Explain the role of reactive power reserve in maintaining voltage stability. Illustrate the concept using a conceptual P-V curve and mark the point that represents the stability limit, beyond which voltage collapse is imminent. (8 marks)

OR

16. (a) Differentiate between an Off-Load Tap Changer (OLTC) and an On-Load Tap Changer (OLTC) used in power transformers. (10 marks)
- (b) State one major advantage and one major disadvantage of using the above for reactive power management compared to a STATCOM (4 marks)
17. (a) Distinguish between Diversity Interchange and Energy Banking as forms of inter utility power exchange. Give a practical scenario for each type of interchange, explaining the economic or resource advantage gained by the participating utilities. (8 marks)
- (b) Differentiate between Capacity Interchange and Emergency Power Interchange agreements between utilities. (6 marks)

OR

18. Introduce the concept of Power System Security. List and briefly explain three major factors that directly affect the overall security of a power system. (14 marks)
19. Compare and contrast Forward Contracts and Future Contracts as they pertain to electricity as a commodity. Also Discuss how 'Options' and 'Contracts for Difference (CfDs)' act as hedging instruments. Provide a hypothetical scenario where a retailer uses a Call Option to protect against a summer heatwave price spike. (14 marks)

OR

20. Explain the relationship and interaction between the Forward Market and the Spot Market in electricity trading. How do market participants utilize financial derivatives, specifically Contracts for Difference (CfD) and Options, to mitigate the risks associated with extreme price volatility in the spot market. (14 marks)

B24EE4P54	CMOS ANALOG CIRCUIT DESIGN	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course aims to impart the basic knowledge in the design of CMOS analog circuits. It focuses on enabling students to analyze and design fundamental analog blocks like current mirrors, amplifiers and CMOS opamps. After the completion of the course, students will be able to design CMOS analog circuits for practical applications.

Prerequisites

Electronic Circuits II

Course Outcomes

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

CO 1	Understand MOS structure and second order effects in MOS. (Cognitive Knowledge Level : Understand)
CO 2	Analyze single stage CMOS amplifiers and differential amplifiers. (Cognitive Knowledge Level : Apply)
CO 3	Analyze the basic biasing techniques and current mirrors. (Cognitive Knowledge Level : Apply)
CO 4	Understand the frequency analysis of amplifiers and applications of PLL. (Cognitive Knowledge Level: Understand)
CO 5	Distinguish between single stage and two stage opamps. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	2	2	1	1	1	1			2
CO 2	3	3	3	2	2	1	1	1	1	1	2
CO 3	3	3	3	2	2	1	1	1	1	1	1
CO 4	3	3	2	2	1	1	1	1	1	1	2
CO 5	3	3	2	2	1	1	1	1	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	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 (7 hours)

MOS Device Physics

Review of MOSFET structure and operation, MOSFET I-V characteristics - threshold voltage, derivation of I-V characteristics, second-order effects - body effect, channel-length modulation, subthreshold conduction, MOS device models - device layout, device capacitances, basic MOS small-signal model - output resistance, body effect represented by a dependent current source.

MODULE 2 (8 hours)

Single stage CMOS Amplifiers

Important aspects of the performance of an amplifier, common-source stage – resistive load, small-signal model, CS stage - diode connected load, current-source load, triode load, source degeneration, source follower, common-gate stage, cascode stage.

Differential Amplifiers

Single-ended and differential operation, basic differential pair, common-mode response, differential pair with MOS loads.

MODULE 3 (7 hours)

Current Mirrors

Biasing requirements in analog circuits, basic biasing techniques, current sources and sinks, basic current mirrors, cascode current mirrors, Wilson current mirrors, current and voltage references - I-V characteristics, bandgap references.

MODULE 4 (7 hours)

Frequency Response of Amplifiers

Miller effect, association of poles with nodes, common-source stage, source followers, common-gate stage, cascode stage, differential pair, effect of high-frequency supply noise in differential pairs.

Phase Locked Loops

Basic PLL topology, simple PLL, charge-pump PLLs, application of PLL - frequency multiplication.

MODULE 5 (7 hours)

CMOS Operational Amplifiers

General considerations - performance parameters, small-signal bandwidth, large-signal bandwidth, output swing, one stage op-amp, cascode op-amps, folded cascode op-amp topology, two-stage op-amps, gain boosting.

Text Books

1. Behzad Razavi, *Design of Analog CMOS Integrated Circuits*, McGraw-Hill, 2nd ed., 2002
2. Phillip E. Allen, Douglas R. Holberg, *CMOS Analog Circuit Design*, TechnoSeries, 2nd ed., 2024.
3. Kenneth Martin Chan Carusone, David Johns, *Analog Integrated Circuit Design*, Wiley, 2nd ed., 2013

Reference Books

1. Razavi B., *Fundamentals of Microelectronics*, Wiley student Edition, 2nd ed., 2014.
2. R Jacob Baker, *CMOS: Circuits Design, Layout and Simulation*, Wiley, 1st, 2009.
3. Adel S Sedra, Kenneth C Smith, Arun N Chandorkar, *Microelectronic Circuits, Theory and Applications*, Oxford, 5th ed., 2012.
4. Sergio Franco, *Design with Operational Amplifiers and Analog Integrated Circuits*, McGraw-Hill, 4th ed., 2016.
5. Thomas L Floyd, David M Buchla, *Fundamentals of Analog Circuits*, Pearson, 2nd ed., 2001.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: MOS Device Physics	7
1.1	Review of MOSFET structure and operation	1
1.2	MOSFET I/V characteristics-threshold voltage	1
1.3	Derivation of I/V characteristics	1
1.4	Second-order effects - body effect, channel-length modulation, subthreshold conduction	1

1.5	MOS device models - device layout, device capacitances	1
1.6	Basic MOS small-signal model	1
1.7	Output resistance, body effect represented by a dependent current source.	1
	Module 2: Single stage CMOS Amplifiers, Differential Amplifiers	8
2.1	Important aspects of the performance of an amplifier	1
2.2	Common-source stage – resistive load, small-signal model	1
2.3	CS stage - diode connected load	1
2.4	Current-source load, triode load	1
2.5	Triode load, source degeneration	1
2.6	Source follower, common-gate stage, cascode stage	1
2.7	Single-ended and differential operation, basic differential pair	1
2.8	Common-mode response, differential pair with MOS loads.	1
	Module 3: Current Mirrors	7
3.1	Biasing requirements in analog circuits	1
3.2	Basic biasing techniques, current sources and sinks	1
3.3	Basic current mirrors, cascode current mirrors	1
3.4	Wilson current mirrors	1
3.5	Current and voltage references	1
3.6	I-V characteristics	1
3.7	Bandgap references .	1
	Module 4: Frequency Response of Amplifiers, Phase Locked Loops	7
4.1	Miller effect, association of poles with nodes	1
4.2	Common-source stage, source followers	1
4.3	Common-gate stage, cascode stage	1
4.4	Differential pair, effect of high-frequency supply noise in differential pairs	1
4.5	Basic PLL topology, simple PLL	1
4.6	Charge-pump PLLs	1
4.7	Application of PLL - frequency multiplication	1
	Module 5: CMOS Operational Amplifiers	7
5.1	General considerations - performance parameters	1
5.2	Small-signal bandwidth, large-signal bandwidth	1
5.3	Output swing, one stage op-amp	1
5.4	Cascode op-amps	1
5.5	Folded cascode op-amp topology	1
5.6	Two-stage op-amps	1
5.7	Gain boosting	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the different regions of operation of a MOSFET.
2. What is meant by channel length modulation?
3. Explain the concept of body effect.

Course Outcome 2 (CO 2)

1. List the important performance parameters of a CMOS amplifier.
2. Explain the principle of a current-source load amplifier.
3. Determine the common-mode gain of a differential amplifier.

Course Outcome 3 (CO 3)

1. What are the basic biasing techniques used in MOS analog circuits?
2. Explain the principle of current mirroring.
3. Compare basic, cascode, and Wilson current mirrors in terms of accuracy and output resistance.

Course Outcome 4 (CO 4)

1. Define the Miller effect. How does it affect amplifier bandwidth?
2. Explain how poles are associated with nodes in a multi-stage amplifier.
3. Compare simple PLL and charge-pump PLL.

Course Outcome 5 (CO 5)

1. List the key performance parameters of a CMOS operational amplifier.
2. Explain the difference between a one-stage opamp and a two-stage opamp in terms of gain and frequency response.
3. Describe the working principle of a cascode opamp and its effect on output resistance.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2028

Course Code: : B24EE4P54

Course Name: : CMOS ANALOG CIRCUIT DESIGN

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define subthreshold conduction.
2. What is the purpose of the body terminal in a MOSFET?
3. Define source degeneration in MOS amplifiers.
4. Explain the concept of common-mode response in differential amplifiers.
5. Define current source and current sink.
6. What are the basic biasing techniques used in MOS analog circuits?
7. Define the Miller effect. How does it affect amplifier bandwidth?
8. Draw the basic PLL topology and label its components.
9. Define small-signal bandwidth and large-signal bandwidth in op-amps.
10. Explain the principle of gain boosting technique in CMOS amplifiers.

PART B

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

11. Explain the structure and operation of a MOSFET. (14 marks)

OR

12. Describe the second order effects of MOSFETs. (14 marks)
13. (a) Draw the circuit diagram of a Common Source amplifier with resistive load and explain its operation. (6 marks)
- (b) Derive expressions for i)Voltage gain ii)Input impedance iii)Output impedance. (8 marks)

OR

14. (a) Draw the circuit diagram of a Common Source amplifier with diode connected load and explain its operation. (6 marks)
- (b) Derive expressions for i)Voltage gain ii)Input impedance iii)Output impedance. (8 marks)
15. Explain the operation of a cascode current mirror. (14 marks)

OR

16. Analyze the working of bandgap references in CMOS analog design. (14 marks)
17. Compare the frequency response of a common-source stage and a source follower. (14 marks)

OR

18. Given a PLL with a VCO gain and loop filter, calculate the lock range and capture range. (14 marks)
19. Compare one-stage and two-stage CMOS operational amplifiers. (14 marks)

OR

20. Compare cascode and folded cascode amplifier topologies. (14 marks)

B24EE4P55	NANO ELECTRONICS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course aims to provide students with a foundational knowledge of nano-scale structures and materials for next-generation electronic applications. It introduces the fundamental concepts of nano science and nano electronic devices emphasizing the scaling limits of conventional electronics, properties of nano materials and fabrication and characterization techniques. This course enables an understanding of nanoscale effects and the operation of nanoelectronic devices in modern applications.

Prerequisites

NIL

Course Outcomes

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

CO 1	Describe the basic concepts of nano electronics and nano materials used for electronic design.(Cognitive Knowledge Level: Remember)
CO 2	Understand the fabrication techniques and various methods used for synthesizing nano structures and nano particles. (Cognitive Knowledge Level: Understand)
CO 3	Understand the characterization techniques and tools used to analyze the structural, optical, and electrical properties of nano materials. (Cognitive Knowledge Level: Understand)
CO 4	Understand the mechanisms of charge transport in nanostructures under electric and magnetic fields.(Cognitive Knowledge Level: Understand)
CO 5	Apply knowledge of nano electronic devices to explain their operation in practical electronic and sensing applications. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	2	2	2	2	1				2
CO 2	3	2	3	2	2	2	1				2
CO 3	3	2	2	3	3	2	1				2
CO 4	3	2	2	3	2	2	1				2
CO 5	3	3	3	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	60	60	40
Apply	0	0	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 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 (7 hours)

Introduction to Nano Electronics

Definition of nano science and nano technology, length scales - micro to nano regime, scaling limits of conventional electronics, quantum mechanics for nano electronics - quantum confinement, quantum wells, wires, and dots.

Nano Materials for Electronics

Classification of nano materials (0D, 1D, 2D, 3D), carbon based nano materials - carbon nano tubes, graphene, fullerenes. Semiconductor nano structures, electrical, optical, and thermal properties of nano materials.

MODULE 2 (8 hours)

Fabrication of Nano Structures

Top-Down Vs Bottom-Up fabrication, Top-Down approaches - electron beam lithography (EBL), focused ion beam (FIB) lithography and nanoimprint lithography, Bottom-Up approaches - chemical vapour deposition (CVD), physical vapour deposition, molecular beam epitaxy, ion implantation, synthesis of nano particle - ball milling, laser ablation, reduction methods, sol gel, self-assembly, precipitation of quantum dots.

MODULE 3 (7 hours)

Characterization of Nanostructures

Tools used for nano material characterization, microscope - optical and electron microscope, scanning electron microscope, scanning tunnelling microscope, atomic force microscope, and transmission electron microscope, X-Ray diffraction analysis, PL and UV spectroscopy, particle size analyzer.

MODULE 4 (6 hours)

Transport of Charge in Nanostructures under Electric Field

Parallel transport, hot electrons, perpendicular transport, quantum transport in nanostructures, Coulomb blockade.

Transport of Charge in Magnetic Field

Effect of magnetic field on a crystal, Aharonov-Bohm effect, Shubnikov-de Hass effect, quantum hall effect.

MODULE 5 (8 hours)

Nano Electronic Devices

Single electron transistor - structure and working principle, V-I characteristics, applications in ultra-low power circuits and memory, Carbon Nano Tube Field Effect Transistor (CNT-FET), Graphene Field Effect Transistor (GFET), molecular electronics - molecular diodes and transistors, spintronic devices - spin valves and spin transistors, applications in magnetic memory, nano wire and nano ribbon devices - semiconductor nano wires (Si, GaN, ZnO) and nano wire FET's, applications in logic devices and sensors, Nano Electronic Mechanical Systems (NEMS), switches and resonators.

Text Books

1. J.M. Martinez-Duart, R.J. Martin Palma, F. Agulle Rueda ,*Nanotechnology for Microelectronics and optoelectronics*, Elsevier, 2nd ed.,2017.
2. Loutfy H. Madkour ,*Nanoelectronic Materials: Fundamentals and Applications*, Springer Nature Switzerland AG, 1st ed.,2019.
3. Mark J Jackson,*Microfabrication and nano manufacturing*, CRC Press, 1st ed.,2005.
4. Brajesh Kumar Kushik, *Nano electronics: devices, circuits and systems*, Elsevier, 1st ed.,2018.
5. K. Goser, P. Glosekotter, J. Dienstuhl,*Nanoelectronics and nanosystems*, Springer, 1st ed.,2004.

Reference Books

1. George W. Hanson *Fundamentals of Nanoelectronics*, Pearson Education,1st ed.,2009.
2. Chattopadhyay, Banerjee, *Introduction to Nanoscience & Technology*, , PHI,1st ed.,2012.
3. Poole, , *Introduction to Nanotechnology* ,John Wiley,1st ed.,2003.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Nano Electronics	7
1.1	Definition of nano science and nano technology	1
1.2	Length scales- micro to nano regime, scaling limits of conventional electronics	1
1.3	Quantum mechanics for nano electronics- quantum confinement, quantum wells, wires, and dots	1
	Nano Materials for Electronics	
1.4	Classification of nano materials (0D,1D,2D,3D), carbon based nano materials- carbon nano tubes, graphene, fullerenes	2
1.5	Semiconductor nano structures	1
1.6	Electrical, optical, and thermal properties of nano materials	1
	Module 2: Fabrication of Nano Structures	8
2.1	Top - Down Vs Bottom - Up fabrication	1
2.2	Top down approaches- Electron Beam Lithography (EBL),	1
2.3	Focused Ion Beam (FIB) lithography and nanoimprint lithography	1
2.4	Bottom-Up approaches- Chemical Vapour Deposition (CVD), physical vapour deposition	2
2.5	Molecular beam epitaxy, ion implantation	1
2.6	Synthesis of nano particle- ball milling, laser ablation, reduction methods	1
2.7	Sol gel, self-assembly, precipitation of quantum dots	1
	Module 3: Characterization of Nanostructures	7
3.1	Tools used for nano material characterization	1
3.2	Microscope- optical and electron microscope	2
3.3	Scanning electron microscope, scanning tunnelling microscope	1
3.4	Atomic force microscope, and transmission electron microscope	1
3.5	X-Ray diffraction analysis	1
3.6	PL and UV spectroscopy, particle size analyzer	1
	Module 4: Transport of Charge in Nanostructures under Electric field	6
4.1	Parallel transport, hot electrons	1
4.2	Perpendicular transport, quantum transport in nanostructures	1
4.3	Coulomb blockade	1
	Transport of Charge in Magnetic field	

4.4	Effect of magnetic field on a crystal	1
4.5	Aharonov-Bohm effect, Shubnikov-de Hass effect	1
4.6	Quantum hall effect	1
	Module 5: Nano Electronic Devices	8
5.1	Single electron transistor- structure and working principle	1
5.2	V-I characteristics , applications in ultra-low power circuits and memory, Carbon Nano Tube Field Effect Transistor (CNTFET)	2
5.3	Graphene Field Effect Transistor (GFET), molecular electronics – molecular diodes and transistors	1
5.4	Spintronic devices – spin valves and spin transistors, applications in magnetic memory	1
5.5	Nano wire and nano ribbon devices- semiconductor nano wires (Si, GaN, ZnO) and nano wire FET's, applications in logic devices and sensors	2
5.6	Nano Electronic Mechanical Systems (NEMS), switches and resonators	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Illustrate how quantum confinement affects the energy levels of electrons in nanostructures.
2. Identify whether the following structures are 0D, 1D, 2D, or 3D nanomaterials.
3. Explain how semiconductor nanostructures improve device performance.
4. Show how size reduction affects electrical conductivity in nanomaterials.

Course Outcome 2 (CO 2)

1. List out top-down and bottom -up fabrication techniques used in nanotechnology.
2. Define the Reduction method for nanoparticle synthesis.
3. Explain how Molecular Beam Epitaxy (MBE) is used for the growth of semiconductor nanostructures.
4. Describe the applications of lithography techniques in nanostructure fabrication.

Course Outcome 3 (CO 3)

1. Name the two main types of electron microscopes used in nanotechnology.
2. List the tools used for characterization of nanomaterials.
3. Describe how Transmission Electron Microscope (TEM) is used to study nanostructures.
4. Describe the importance of particle size measurement in nanomaterial characterization.

Course Outcome 4 (CO 4)

1. Describe the relationship between magnetic field effects and quantum transport phenomena.
2. Explain the importance of studying charge transport mechanisms in nanoelectronic devices.
3. Describe the Aharonov–Bohm effect and Shubnikov–de Haas effect in nanostructures and explain the significance of both in nanomaterial studies.
4. Explain the difference between classical transport and quantum transport in nanostructures.

Course Outcome 5 (CO 5)

1. Illustrate how a Single Electron Transistor (SET) can be used in ultra-low power electronic circuits.
2. Explain how a Graphene Field Effect Transistor (GFET) can be applied in high-speed electronic devices.
3. Explain how molecular transistors can function as switching elements in nano circuits.
4. Explain how NEMS resonators can be applied in sensing and signal processing.

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: : B24EE4P55

Course Name: : NANO ELECTRONICS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define nanoscience and nanotechnology. Explain the length scale from micro to nano regime?
2. Discuss the electrical, optical, and thermal properties of nanomaterials.
3. Differentiate between Top-Down and Bottom-Up fabrication approaches used in nanos-structure fabrication.
4. Explain the principle of Chemical Vapour Deposition (CVD) used in nanomaterial synthesis.
5. Explain the working principle of a Scanning Electron Microscope (SEM).
6. What is a Scanning Tunnelling Microscope (STM)?
7. Briefly explain quantum transport in nanostructures.
8. What is a single electron transistor (SET) and how is it related to Coulomb blockade?
9. List the advantages of CNTFET over conventional MOSFET.
10. Mention any three important properties of graphene used in GFET.

PART B

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

11. (a) Explain the concept of quantum confinement in nanoelectronics. (4 marks)
(b) Describe quantum wells, quantum wires, and quantum dots with suitable diagrams. (10 marks)

OR

12. (a) Discuss semiconductor nanostructures and explain the electrical, optical, and thermal properties of nanomaterials. (8 marks)
(b) Classify nanomaterials based on dimensions (0D, 1D, 2D, 3D) . (6 marks)
13. (a) Discuss the Bottom-Up fabrication techniques for nanostructures. (4 marks)
(b) Explain Chemical Vapour Deposition (CVD), Physical Vapour Deposition (PVD), Molecular Beam Epitaxy (MBE), and Ion Implantation. (10 marks)

OR

14. Explain different methods used for the synthesis of nanoparticles such as ball milling, laser ablation, reduction methods, sol-gel process, self-assembly, and precipitation of quantum dots. . (14 marks)
15. (a) Differentiate between optical microscope and electron microscope. (4 marks)
(b) Explain the techniques used for nanomaterial analysis such as PL spectroscopy, UV spectroscopy, and particle size analyzer with their principles and applications. (10 marks)

OR

16. (a) Write a short note on particle size analyzer. (4 marks)
(b) Explain the techniques used for nanomaterial analysis such as PL spectroscopy and UV spectroscopy with their principles and applications. (10 marks)
17. (a) What are the main features of the Quantum Hall Effect? (4 marks)
(b) Discuss the differences between classical transport and quantum transport in nanostructures. Explain how electric fields influence electron motion at the nanoscale. (10 marks)

OR

18. (a) Distinguish between classical Hall effect and quantum Hall effect. (6 marks)
(b) Describe How magnetic fields influence electron transport in nanostructures. Discuss the Aharonov–Bohm effect and Shubnikov–de Haas effect. (8 marks)
19. (a) Discuss the advantages and limitations of Single Electron Transistors in nano-electronic applications. (7 marks)
(b) Describe the V–I characteristics of a Single Electron Transistor. Explain how it is used in ultra-low power circuits and memory devices. (7 marks)

OR

20. (a) Compare CNTFET and GFET devices in terms of structure, electrical properties, and performance. (7 marks)
(b) Explain the structure and operation of Graphene Field Effect Transistor (GFET). Discuss its advantages and applications. (7 marks)

B24EE4P56	DEEP LEARNING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The course outline the knowledge and skills students will gain in deep learning concepts and techniques. This emphasize understanding, applying, and evaluating various deep learning models for real-world problems. This prepare learners to design and analyze advanced deep learning architectures effectively.

Prerequisites

Basics of Linear Algebra and Probability

Course Outcomes

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

CO 1	Demonstrate basic concepts in machine learning. (Cognitive Knowledge Level: Understand)
CO 2	Illustrate the validation process of machine learning models using hyper-parameters and validation sets. (Cognitive Knowledge Level: Understand)
CO 3	Demonstrate the concept of the feed forward neural network and its training process. (Cognitive Knowledge Level: Apply)
CO 4	Build CNN and Recurrent Neural Network (RNN) models for different use cases. (Cognitive Knowledge Level: Apply)
CO 5	Use different neural network/deep learning models for practical applications. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	40	20	20
Understand	60	40	40
Apply		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 (8 hours)

Introduction to Deep Learning

Key components - data, models, objective functions, optimization algorithms, learning algorithms. Supervised learning - regression, classification, tagging, web search, page ranking, recommender systems, sequence learning, unsupervised learning, reinforcement learning, historical trends in deep learning. Other concepts - overfitting, underfitting, hyper-parameters and validation sets, estimators, bias, and variance.

MODULE 2 (9 hours)

Optimization and Neural Networks

Neural Networks - perceptron, gradient descent solution for perceptron, multilayer perceptron, activation functions, architecture design, chain rule, back propagation, gradient based learning. Introduction to optimization - gradient based optimization, linear least squares. Stochastic gradient descent, building ML algorithms and challenges

MODULE 3 (7 hours)

Convolutional Neural Network

Convolutional neural networks - convolution operation, motivation, pooling, convolution and pooling as an infinitely strong prior, variants of convolution functions, structured outputs, data types, efficient convolution algorithms.

MODULE 4 (7 hours)

Recurrent Neural Network

Recurrent neural networks - computational graphs, RNN design, encoder-decoder sequence to sequence architectures, deep recurrent networks, recursive neural networks, modern RNNs LSTM and GRU, practical use cases for RNNs

MODULE 5 (5 hours)

Application Areas

Applications - computer vision, speech recognition, natural language processing. Research areas - autoencoders, representation learning, Boltzmann machines, deep belief networks.

Text Books

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press 2015 ed.
2. Aston Zhang, Zachary C. Lipton, Mu Li, and Alexander J. Smola, Dive into Deep Learning, August 2019.
3. Neural Networks and Deep Learning: A Textbook by Charu C. Aggarwal. Springer.1st edition, 2018.

Reference Books

1. Neural Smithing: Supervised Learning in Feed forward Artificial Neural Networks by Russell Reed, Robert J MarksII, 1st edition, 1999, MIT Press.
2. Practical Convolutional Neural Networks by Mohit Sewak, Md. Rezaul Karim, Pradeep Pujari, 1st edition, 2018, Packt Publishing Ltd.
3. Hands-On Deep Learning Algorithms with Python by Sudharsan Ravichandran, 1st edition, 2019, Packt Publishing Ltd

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Deep Learning	8
1.1	Key components - data, models, objective functions, optimization algorithms	1
1.2	Learning algorithm, supervised learning - regression, classification, tagging, web search, page ranking	1
1.3	Recommender systems, sequence learning, unsupervised learning, reinforcement learning	1
1.4	Historical trends in deep learning.	1
1.5	Concepts: overfit, underfit, hyper-parameters and validation sets	1
1.6	Concepts - estimators, bias and variance. Demonstrate the concepts of supervised learning algorithms using a suitable platform	1
1.7	Demonstrate the concepts of supervised learning algorithms using a suitable platform	1
1.8	Demonstrate the concepts of unsupervised using a suitable platform	1
	Module 2: Optimization and Neural Networks	9

2.1	Perceptron, stochastic gradient descent, gradient descent solution for perceptron	1
2.2	Multilayer perceptron	1
2.3	Activation functions - sigmoid, tanh, softmax, ReLU, leaky ReLU	1
2.4	Architecture design	1
2.5	Chain rule, back propagation	1
2.6	Gradient based learning	1
2.7	Gradient based optimization	1
2.8	Linear least squares using a suitable platform.	1
2.9	Building ML algorithms and challenges	1
	Module 3:Convolutional Neural Network	7
3.1	Convolution operation	1
3.2	Motivation, pooling	1
3.3	Convolution and pooling as an infinitely strong prior	1
3.4	Variants of convolution functions – multilayer convolutional network, tensors, kernel flipping, downsampling, strides and zero padding	1
3.5	Variants of convolution functions - unshared convolutions, tiled convolution, training different networks	1
3.6	Structured outputs, data types	1
3.7	Efficient convolution algorithms, case study: AlexNet, VGG, ResNet.	1
	Module 4: Recurrent Neural Network	7
4.1	Computational graphs	1
4.2	RNN	1
4.3	Encoder - decoder sequence to sequence architectures	1
4.4	Deep recurrent networks	1
4.5	Recursive neural networks, modern RNNs, LSTM and GRU	1
4.6	Practical use cases for RNNs	1
4.7	Demonstrate the concepts of RNN using a suitable platform.	1
	Module 5: Applications and Research	5
5.1	Computer vision	1
5.2	Speech recognition	1
5.3	Natural language processing	1
5.4	Brief introduction on current research areas- autoencoders, representation learning	1
5.5	Brief introduction on current research areas- Boltzmann Machines, deep belief networks.	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Compare regression and classification.
2. Discuss the different learning approaches used in machine learning.
3. Sketch the typical learning curves for the training and validation sets, for a setting where overfitting occurs at some point. Assume that the training set and the validation set are of the same size

Course Outcome 2 (CO 2)

1. What are hyperparameters? Why are they needed?
2. Draw the architecture of a multi-layer perceptron.
3. Consider training a fully-connected neural network with 5 hidden layers, each with 10 hidden units. The input is 20-dimensional and the output is a scalar. What is the total number of trainable parameters in your network?.

Course Outcome 3 (CO 3)

1. Give two benefits of using convolutional layers instead of fully connected ones for visual tasks
2. Weight sharing allows CNNs to deal with image data without using too many parameters. Does weight sharing increase the bias or the variance of a model?
3. Consider a convolution layer. The input consists of 6 feature maps of size 20 x 20. The output consists of 8 feature maps, and the filters are of size 5 x 5. The convolution is done with a stride of 2 and zero padding, so the output feature maps are of size 10 x 10. Determine the number of weights in this convolution layer

Course Outcome 4 (CO 4)

1. Explain how the cell state is updated in the LSTM model from C_{t-1} to C_t
2. Briefly explain how “unrolling through time” is related to “weight sharing” in convolutional networks.
3. Show the steps involved in an LSTM to predict stock prices. Give one advantage of using an RNN rather than a convolutional network.

Course Outcome 5 (CO 5)

1. Sketch the architecture of an autoencoder network.
2. Describe how to train an autoencoder network.
3. Write down the formula for the energy function (E) of a Restricted Boltzmann Machine (RBM).



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: : B24EE4P56

Course Name: : DEEP LEARNING

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Distinguish between supervised learning and Reinforcement learning. Illustrate with an example.
2. Illustrate the concepts of Web search, Page Ranking, Recommender systems.
3. Compare overfitting and underfitting. How it can affect model generalization.
4. Why does a single perceptron cannot simulate simple XOR function?
5. Illustrate the strengths and weaknesses of convolutional neural networks.
6. Illustrate convolution and pooling operation with an example
7. How many parameters are there in AlexNet? Why the dataset size (1.2 million) is important for the success of AlexNet? .
8. Explain your understanding of unfolding a recursive or recurrent computation into a computational graph.
9. Illustrate the use of deep learning concepts in Speech Recognition.
10. What is an autoencoder? Give one application of an autoencoder.

PART B

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

11. “A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P , if its performance at tasks in T , as measured by P , improves with experience E .” What is your understanding of the terms task, performance and experience. Explain with two examples. (14 marks)

OR

12. Sketch the typical learning curves for the training and validation sets, for a setting where overfitting occurs at some point. Assume that the training set and the validation set are of the same size. (14 marks)
13. (a) How do multilayer neural networks learn and encode higher level features from input features? (7 marks)
- (b) Explain gradient descent and delta rule? Why is stochastic approximation to gradient descent needed? (7 marks)

OR

14. (a) Write an algorithm for backpropagation which uses stochastic gradient descent method. Comment on the effect of adding momentum to the network. (6 marks)
- (b) Consider a convolution layer. The input consists of 6 feature maps of size 20×20 . The output consists of 8 feature maps, and the filters are of size 5×5 . The convolution is done with a stride of 2 and zero padding, so the output feature maps are of size 10×10 . Determine the number of weights in this convolution layer. (8 marks)
15. (a) Input to CNN architecture is a color image of size $112 \times 112 \times 3$. The first convolution layer comprises of 64 kernels of size 5×5 applied with a stride of 2 and padding 0. What will be the number of parameters? (7 marks)
- (b) Draw and explain the architecture of a convolutional network. (7 marks)

OR

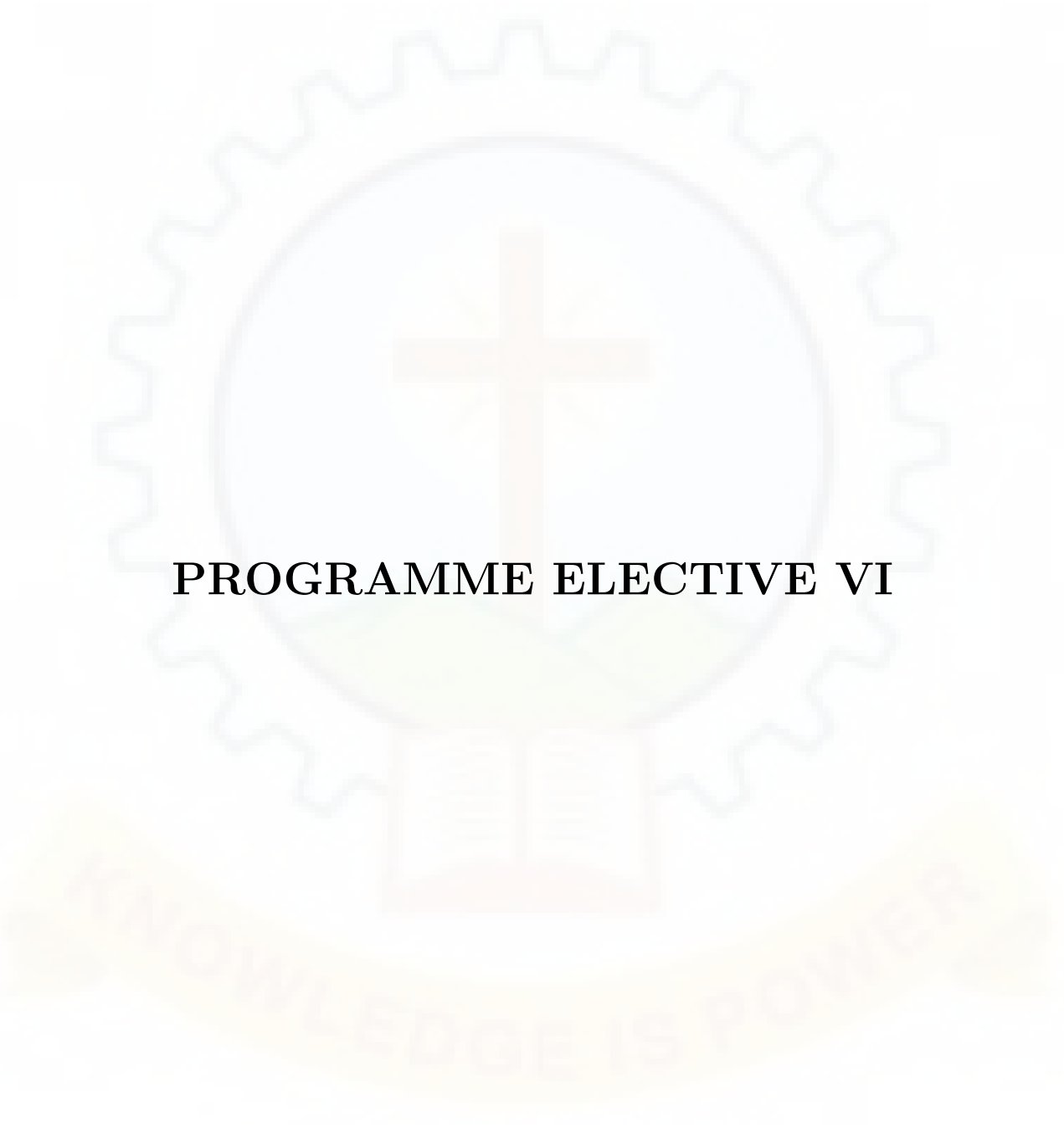
16. (a) How is backpropagation used to learn higher-order features in a convolutional Network? (4 marks)
- (b) Explain the concept behind i) Early stopping ii) dropout iii) weight decay (10 marks)
17. (a) How is backpropagation used to learn higher-order features in a convolutional Network? (8 marks)
- (b) Describe the working of a long short term memory in RNNs. (6 marks)

OR

18. (a) Why do RNNs have a tendency to suffer from exploding/vanishing gradient? How to overcome this challenge? . (6 marks)
- (b) What is the vanishing gradient problem and exploding gradient problem? (8 marks)
19. (a) Explain any two word embedding techniques. (8 marks)
- (b) Explain the merits and demerits of using Auto encoders in Computer Vision. (6 marks)

OR

20. (a) Illustrate the use of representation learning in object classification. (7 marks)
- (b) Compare Boltzmann Machine with Deep Belief Network. (7 marks)



PROGRAMME ELECTIVE VI

B24EE4P61	PROCESS CONTROL AND INSTRUMENTA- TION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The aim of this course is to introduce the fundamentals and applications of process control systems used in chemical and thermal plant operations. The course content covers dynamic behaviour of processes, design and tuning of controllers, and advanced control techniques. Upon successful completion, students will be able to analyze, design, and apply appropriate control strategies and measurement techniques for stable, efficient, and safe operation of industrial processes.

Prerequisites

Linear Control System, Instrumentation Systems

Course Outcomes

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

CO 1	Model the level, pressure, and thermal processes by understanding process control principles.(Cognitive Knowledge Level: Apply)
CO 2	Analyze dynamic system behaviour of various process control systems. (Cognitive Knowledge Level: Apply)
CO 3	Design and model chemical process systems using appropriate controllers, sensors, and actuators. (Cognitive Knowledge Level: Apply)
CO 4	Design and tune feedback control systems using various methods. (Cognitive Knowledge Level: Apply)
CO 5	Understand various advanced control techniques in process control. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	3	1		1	1				2
CO 2	3	2	1	1			1				2
CO 3	3	2	3	1		1	1				2
CO 4	3	2	3	1		1	1				2
CO 5	3	2	1	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	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 (7 hours)

Introduction to Process Control

Principle, identification of elements, and block diagram of the process control loop, process control drawings. Variables in chemical process, design elements and hardware elements of control system, mathematical model of level, pressure, and thermal processes, dead time, degrees of freedom.

MODULE 2 (7 hours)

Dynamic Behaviour of Processes

First order systems - processes modelled as first order systems, dynamic response of pure capacitive and first order lag system, system with variable time constant and gain.

Second order systems - dynamic response, interacting and non-interacting systems, dynamic behaviour of higher order systems - systems with dead time.

MODULE 3 (9 hours)

Introduction to Feedback Control

Concept of feedback control, type of feedback controllers - P, PI, and PID, effect of proportional, integral, derivative and composite control actions.

Control configurations for multiple-input, multiple-output (MIMO) processes - design questions, degrees of freedom, number of controlled and manipulated variables, generation of alternative loop configurations, extensions to systems with interacting units.

Measuring devices - flow, pressure, and temperature sensors, transmission lines, final control operation - elements of final control operation, signal conversion - analog, digital, and pneumatic signals, actuators - electrical, pneumatic, and hydraulic, control elements - mechanical, electrical, and fluid valves.

MODULE 4 (7 hours)

Design of Feedback Control System

Performance criteria - integral of the square error (ISE), Integral of the absolute value of the error (IAE), Integral of the time - weighted absolute error (ITAE) and $\frac{1}{4}$ decay ratio, selection of feedback controller, controller tuning - process reaction curve method, Ziegler Nichols method, damped oscillation method, two-point method, process identification.

MODULE 5 (6 hours)

Advanced Control Techniques

Cascade, split range, feed forward, ratio, adaptive, inferential, smith predictor, and internal model control.

Text Books

1. Stephanopoulos G., *Chemical Process Control: An Introduction to Theory and Practice*, Pearson Education India, 1st ed., 2015.
2. Curtis D Johnson, *Process Control Instrumentation Technology*, Pearson New International Edition, 8th ed., 2005.
3. Donald.R. Coughanour and Steven.E. LeBlanc, *Process Systems analysis and Control*, McGraw- Hill, 3rd ed., 2009.
4. Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp, and Francis J. Doyle, *Process Dynamics and Control*, Wiley, 4th ed., 2016.

Reference Books

1. John G Webster, *Measurement, Instrumentation and Sensors Handbook*, CRC press, 1999.
2. Patranabis. D, *Principles of Industrial Instrumentation*, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 3rd ed., 2010.
3. Thomas E Marlin, *Process Control-Designing processes and control systems for dynamic performance*, McGraw- Hill., 2nd ed., 2009.
4. Liptak B.G, *Instrumentation Engineers Handbook (Measurement)*, Chilton Book Co., 1994.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Process Control	7
1.1	Principle, identification of elements, and block diagram of the process control loop	1
1.2	Process control drawings	1
1.3	Variables in chemical process	1
1.4	Design elements and hardware elements of control system	1

1.5	Mathematical model of level, pressure, and thermal processes	2
1.6	Dead time, degrees of freedom	1
	Module 2:Dynamic behaviour of processes	7
2.1	First order systems - processes modelled as first order systems	1
2.2	Dynamic response of pure capacitive and first order lag system	1
2.3	System with variable time constant and gain	1
2.4	Second order systems - dynamic response	1
2.5	Interacting and non-interacting systems	2
2.6	Dynamic behaviour of higher order systems - systems with dead time	1
	Module 3: Introduction to Feedback control	9
3.1	Concept of feedback control	1
3.2	Type of feedback controllers - P, PI, and PID, effect of proportional, integral, derivative and composite control actions	1
3.3	Control configurations for multiple - input, multiple - output (MIMO) processes - design questions, degrees of freedom, number of controlled and manipulated variables	1
3.4	Generation of alternative loop configurations, extensions to systems with interacting units	1
3.5	Measuring devices - flow, pressure, and temperature sensors	1
3.6	Transmission lines, final control operation - elements of final control operation	1
3.7	Signal conversion - analog, digital, and pneumatic signals	1
3.8	Actuators - electrical, pneumatic, and hydraulic	1
3.9	Control elements - mechanical, electrical, and fluid valves	1
	Module 4:Design of feedback control system	7
4.1	Performance criteria- Integral of the square error (ISE), Integral of the absolute value of the error (IAE), Integral of the time - weighted absolute error (ITAE) and $\frac{1}{4}$ decay ratio.	2
4.2	Selection of feedback controller	1
4.3	Controller tuning - process reaction curve method	1
4.4	Ziegler Nichols method	1
4.5	Damped oscillation method, two-point method	1
4.6	Process identification	1
	Module 5:Advanced Control Techniques	6
5.1	Cascade and split range control	2
5.2	Feed forward and ratio control	2
5.3	Adaptive and inferential control	1
5.4	Smith predictor and internal model control	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the block diagram of the process control loop.
2. Explain the and hardware elements of control system.
3. Develop mathematical model of level, pressure, and thermal processes.

Course Outcome 2 (CO 2)

1. Derive transfer function of processes modelled as first order system.
2. Analyse the dynamic response of second order system.
3. Explain the dynamic behaviour of systems with dead time.

Course Outcome 3 (CO 3)

1. Explain the effect of proportional, integral, derivative and composite control actions.
2. Illustrate the elements of final control operation.
3. Describe the working of actuators used in process control.

Course Outcome 4 (CO 4)

1. Evaluate the dynamic performance of a closed loop system based on performance criteria.
2. Identify the proper feedback controller used to control a given process.
3. Explain the various controller tuning processes.

Course Outcome 5 (CO 5)

1. Explain the working principle of cascade control and feed-forward control with suitable examples.
2. Describe the concept of split-range control and ratio control.
3. Explain the principles of adaptive control, inferential control, Smith predictor, and internal model control in process control systems.

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: : B24EE4P61

Course Name: : PROCESS CONTROL AND INSTRUMENTATION

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Illustrate the block diagram of the process control loop and explain each element.
2. Explain the classification of variables in a chemical process.
3. What is mean by exponential transfer lag?
4. Differentiate between interacting and non-interacting capacities.
5. With necessary diagram illustrate the operation of pneumatic valves.
6. What are the basic hardware components of a feedback control loop ?
7. List out the various steps for selecting type of feedback controller.
8. Distinguish between ISE and IAE with regard to controller performance evaluation criteria.
9. Using an appropriate example explain about split range control.
10. Discuss about the advantage of inferential control over normal feedback control.

PART B

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

11. (a) With neat diagram explain various types of control configurations. (8 marks)
(b) Develop the mathematical model of a tubular heat exchanger. (6 marks)

OR

12. Explain the various hardware elements of a control system. Also illustrate the hardware elements for the feedback control of a stirred tank heater. (14 marks)
13. (a) Derive the transfer function of a first order system with a capacity for energy storage. (7 marks)
(b) Illustrate and explain the dynamic response of a first order lag system to step input change. (7 marks)

OR

14. The tank shown in fig.1 is a first order system. In order to control the liquid level at a desired value when the inlet flow rate F_i undergoes step changes, design a suitable feedback control system. Also plot the resulting second order behaviour of the liquid level. (14 marks)

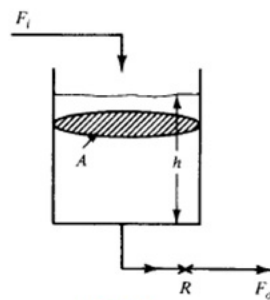
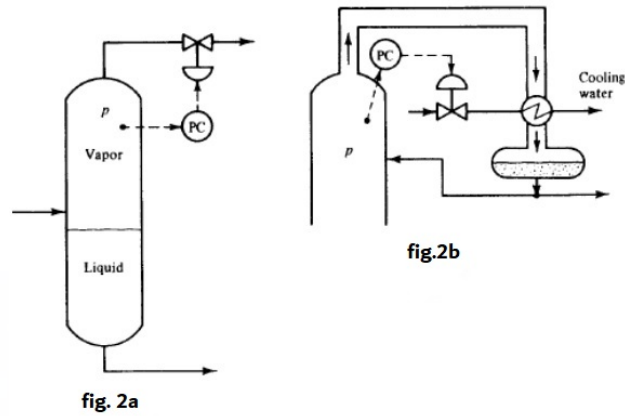


fig. 1

15. (a) Explain different types of measuring devices used in process control. (9 marks)
(b) Explain the effect of PI controller on system response. (5 marks)

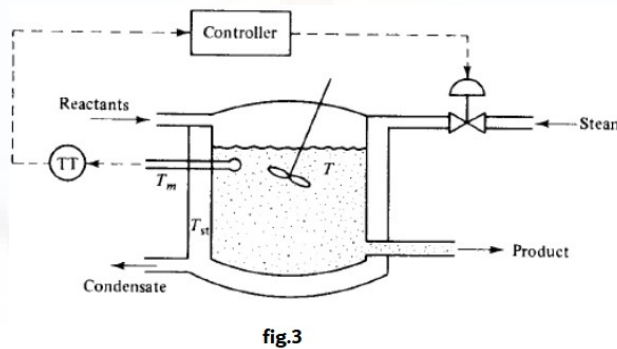
OR

16. (a) Explain different types of actuators used in process control. (9 marks)
(b) Explain the significance of derivative term in PID controller. What are the major drawbacks of the derivative control action? (5 marks)
17. (a) Explain the Ziegler Nichols closed loop method for controller tuning and write the parameters for different controller modes. How does it differ from damped oscillation method? (7 marks)
(b) For the following pressure control loops given in fig.2a and fig.2b, choose the most suitable controllers for controlling pressure. (7 marks)



OR

19. (a) The temperature control system in a jacketed CSTR is given below (fig.3). The objective is to keep temperature of the reacting mixture at desired level. Reaction is endothermic and is accomplished by manipulating the flow of steam in the jacket around the reactor. Choose a suitable controller for keeping the temperature at desired level. (7 marks)



- (b) Explain the process reaction curve method for controller tuning and write the parameters for different controller modes. How does it differ from two point method? (7 marks)
19. (a) What is Smith predictor? Explain using appropriate mathematical analysis. (7 marks)
- (b) Explain the cascade control for a jacketed CSTR with necessary schematic diagrams. Compare the cascade control with conventional feedback control. (7 marks)

OR

20. (a) Explain override control technique for the protection of process equipment with necessary examples. (7 marks)
- (b) What are the relative advantages and disadvantages of feedforward and feedback control. (7 marks)

B24EE4P62	POWER CONVERTERS FOR POWER SYSTEM APPLICATIONS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Power electronic converters play an important role in modern power systems by enabling efficient generation, transmission, control, and utilization of electrical energy. With the large-scale integration of renewable energy sources such as photovoltaic and wind power systems, advanced converter topologies and control strategies have become indispensable. This course provides a comprehensive understanding of voltage-sourced converters (VSCs), their operating principles, modulation techniques, harmonic performance, and control methods in grid-connected applications.

Prerequisites

Power Electronics, Power Systems.

Course Outcomes

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

CO 1	Explain the role of power electronic converters in power systems and classify FACTS devices and converter topologies used for power system applications. (Cognitive Knowledge Level: Understand).
CO 2	Analyze the operation, harmonic performance, and modulation techniques of single phase two level voltage source converters. (Cognitive Knowledge Level: Analyse).
CO 3	Analyze three phase two level VSCs under square wave and PWM operation, including harmonic elimination and DC voltage utilization. (Cognitive Knowledge Level: Analyse).
CO 4	Apply control techniques in the $\alpha - \beta$ frame for real and reactive power control of grid connected voltage-source converters. (Cognitive Knowledge Level: Apply).
CO 5	Explain grid converter configurations and control strategies for photovoltaic and wind energy systems. (Cognitive Knowledge Level: Understand).

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2					1				1
CO 2	3	2	1	2	2		1				1
CO 3	3	2		2	2		1				1
CO 4	3	3	2	2	3		1				2
CO 5	3	3	2	2	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	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 (6 hours)

Electronic Power Conversion

Introduction - power electronic converters and converter systems, applications in power systems, principle of power transmission - shunt compensators, series compensators, comparison of compensators, classification of converters based on commutation process, terminal voltage and waveforms, voltage source converters (VSC) - basic configurations - single phase half bridge, full bridge, multimode VSC, multilevel VSC.

MODULE 2 (7 hours)

Single Phase Two-level VSC

Half bridge and full bridge square wave switching, harmonic performance, voltage regulated two level VSC - single PWM, multiple PWM, sinusoidal pulse width modulation (SPWM), modified SPWM, phase displacement control, bipolar vs unipolar SPWM, harmonics and filtering, leakage current issue in SPWM, current regulated two - level VSC - introduction, application in power systems - grid side current regulation - hysteresis control, boost inverter.

MODULE 3 (7 hours)

Three Phase Two-level VSC

Basic 6 pulse three phase inverter - 180 degree and 120 degree square wave operation, analysis - R and RL load, 2 level three phase VSC - Programmed Harmonic Elimination (PHE), implementation, SPWM - harmonics, choice of carrier frequency, DC voltage utilisation, third harmonic injection, filtering requirements, Space Vector Modulation (SVM) - motivation, switching states, space vectors.

MODULE 4 (8 hours)

Control of Grid Imposed Frequency VSC in α - β Frame

Structure of grid-imposed frequency VSC system, real/reactive power control - current mode Vs voltage mode control, model of real/reactive power controller - α - β frame, current mode control - real/reactive power in α - β frame, selection of DC bus voltage level, controlled DC voltage power port - model in α - β frame, DC bus voltage control in α - β frame.

MODULE 5 (8 hours)

Grid Converters for Photovoltaic and Wind Power Systems

Grid integration of WT and PV system, photovoltaic inverter structures - inverter derived from H-bridge topology, basic full bridge inverter, H5 inverter (SMA), HERIC inverter (Sunways), REFU inverter, full bridge inverter with DC bypass - FB-DCBP, full bridge zero voltage rectifier - FB-ZVR, PV inverter with boost stage - generic control structure.

Grid converter structures for wind turbine systems - WTS power configurations, grid power converter topologies - Single Cell (VSC or CSC), multicell (Interleaved or Cascaded). WTS control-generator side control, WTS grid control.

Text Books

1. Amirnaser Yazdani & Reza Iravani, *Voltage-Sourced Converters in Power Systems*, IEEE Press, John Wiley & Sons, 2010.
2. Remus Teodorescu, Marco Liserre and Pedro Roderiguez Bin Wu, *High Power Converters and AC Drives*, IEEE Press, John Wiley & Sons, 2006.
3. Remus Teodorescu, Marco Liserre and Pedro Rodriguez, *Grid Converters for Photovoltaic and Wind Power System*, IEEE Press, John Wiley & Sons, 2011.
4. Narain G. Hingorani and Laszlo Gyugyi, *Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems*, IEEE Press, 2000.
5. Mohan, Ned, Tore M. Undeland, and William P. Robbins, *Power electronics: converters, applications, and design*, John wiley and sons, 2003.
6. Muhammad H. Rashid, *Power Electronics*, Third Edition, Pearson Education, 2004.

Reference Books

1. Daniel W. Hart, *Power Electronics*, McGraw Hill Co. Ltd., India, 2010.
2. Haadi A. Sadat, *Power System Analysis*, McGraw Hill Co. Ltd., India, 2000.
3. P.C. Sen, *Power Electronics*, McGraw Hill Co. Ltd., Tata McGraw Hill, 2003.
4. G.K.Dubey et.al, *Thyristorised Power Controllers*, Wiley Eastern Ltd., 2005.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Electronic Power Conversion	6
1.1	Introduction - power electronic converters and converter systems, applications in power systems.	1
1.2	Principle of power transmission, shunt compensators - TCR, TSC, static VAR compensator.	1
1.3	Series compensators - TSSC, TCSC, FCSC, SSVC, UPFC, comparison of compensators.	1
1.4	Classification of converters based on - commutation process, terminal voltage and waveforms, voltage source converters (VSC).	1
1.5	Basic configurations - single phase half bridge, full bridge, multimode VSC, multilevel VSC.	2
	Module 2: Single Phase Two-level VSC	7
2.1	Half-bridge and full bridge square wave switching, harmonic performance.	2
2.2	Voltage regulated two level VSC - single PWM, multiple PWM, sinusoidal pulse width modulation (SPWM), modified SPWM, phase displacement control.	2
2.3	Bipolar vs. unipolar SPWM, harmonics and filtering, leakage current issue in SPWM.	1
2.4	Current regulated two level VSC - introduction, application in power systems - grid side current regulation — hysteresis control.	1
2.5	Boost inverter.	1
	Module 3: Three Phase Two-level VSC	7
3.1	Basic 6-pulse three-phase inverter-180 degree and 120 degree square wave operation - analysis - R and RL load.	2
3.2	2-Level three-phase VSC - Programmed Harmonic Elimination (PHE), implementation.	1
3.3	SPWM - harmonics, choice of carrier frequency.	1
3.4	DC voltage utilisation, third harmonic injection, filtering requirements.	1
3.5	Space Vector Modulation (SVM) - motivation, switching states, space vectors.	2
	Module 4: Control of Grid Imposed Frequency VSC in $\alpha - \beta$ Frame	8
4.1	Structure of grid-imposed frequency VSC system, real/reactive power control – current mode vs voltage mode control.	2
4.2	Model of real/reactive power controller - $\alpha - \beta$ frame.	1

4.3	Current mode control - real/reactive power in $\alpha - \beta$ frame, selection of DC bus voltage level.	2
4.4	Controlled DC voltage power port - model in $\alpha - \beta$ frame.	2
4.5	DC bus voltage control in $\alpha - \beta$ frame.	1
	Module 5:Grid Converters for Photovoltaic and Wind Power Systems	8
5.1	Grid integration of WT and PV system, photovoltaic inverter structures-inverter derived from H-bridge topology, basic full bridge inverter, H5 inverter (SMA), HERIC inverter (Sunways), REFU inverter.	2
5.2	Full bridge inverter with DC bypass - FB-DCBP, full bridge zero voltage rectifier - FB-ZVR, PV inverter with boost stage-generic control structure.	2
5.3	Grid converter structures for wind turbine systems - WTS power configurations.	1
5.4	Grid power converter topologies - Single-Cell (VSC or CSC), multicell (Interleaved or Cascaded).	2
5.5	WTS control - generator side control, WTS grid control.	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the importance of power electronic converters in modern power systems with examples.
2. Compare the working principle of TCR and TSC.
3. Classify FACTS devices based on connection type (series, shunt, combined).

Course Outcome 2 (CO 2)

1. Analyze the harmonic performance of single-phase VSC.
2. Compare single PWM and multiple PWM techniques.
3. Explain hysteresis current control for grid-side current regulation.

Course Outcome 3 (CO 3)

1. Derive the line voltage waveform for 180° conduction mode.
2. Discuss the choice of carrier frequency in SPWM.

3. Describe the Space Vector Modulation (SVM) technique.

Course Outcome 4 (CO 4)

1. Explain the structure of grid-imposed frequency VSC system.
2. Derive the real and reactive power equations in $\alpha - \beta$ frame.
3. Develop the control block diagram for grid-connected VSC.

Course Outcome 5 (CO 5)

1. Explain the grid integration of photovoltaic systems.
2. Explain the working of H5 inverter topology.
3. Describe generator-side control and grid-side control in WTS.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2028

Course Code: : B24EE4P62

Course Name: : POWER CONVERTERS FOR POWER SYSTEM APPLICATIONS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the operation of Static VAR Compensator.
2. Classify converters based on commutation process and waveform type.
3. Explain the working principle of Sinusoidal Pulse Width Modulation (SPWM).
4. Explain the leakage current issue in SPWM in grid-connected systems.
5. Describe the concept of Programmed Harmonic Elimination (PHE).
6. Discuss the third harmonic injection and its advantages.
7. Compare current-mode and voltage-mode control of VSC system.
8. What is real and reactive power control in VSC?
9. Describe the full bridge inverter with DC bypass (FB-DCBP).
10. Give a brief explanation on wind turbine system (WTS) power configurations.

PART B

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

11. (a) Explain the role of power electronic converters in modern power transmission systems. (6 marks)

- (b) Explain the operation of shunt compensators such as TCR and TSC with neat diagrams. (8 marks)

OR

12. (a) Explain different FACTS devices used in power systems and their applications. (8 marks)
(b) Classify converters based on commutation process and terminal voltage waveforms. (6 marks)
13. (a) Explain the operation of single-phase full-bridge inverter with square-wave switching. (8 marks)
(b) Discuss the harmonic performance and filtering requirements. (6 marks)

OR

14. (a) Compare bipolar and unipolar SPWM. (6 marks)
(b) Explain hysteresis current control for grid-side current regulation. (8 marks)
15. (a) Explain the 120° conduction mode of the three-phase inverter with phase voltage and line voltage waveforms. (10 marks)
(b) Compare 120° and 180° conduction modes of three phase inverters. (4 marks)

OR

16. (a) A three-phase two-level inverter uses Space Vector Modulation to generate an output voltage. Explain the concept of space vectors and switching states of a three-phase inverter. (5 marks)
(b) Derive the expression for time duration of adjacent vectors and zero vectors used to synthesize the reference vector. (5 marks)
(c) Explain the switching sequence used in SVM for one sampling period. (4 marks)
17. Explain the structure of grid-imposed frequency VSC system. Derive real and reactive power control equations in $\alpha - \beta$ frame. (14 marks)

OR

18. Explain current-mode control in grid connected converters. Discuss DC bus voltage control in $\alpha - \beta$ frame. (14 marks)
19. Explain the working of H5 and HERIC inverter topologies. (14 marks)

OR

20. Discuss generator-side and grid-side control in WTS. (14 marks)

B24EE4P63	SMART GRID TECHNOLOGIES	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course aims the students to understand the basic concepts of smart grid, its applications and the utilisation of electrical power through advanced communication. This course introduces the evolution of smart power grids, its development, monitoring and control, communication systems, cloud computing and cybersecurity. The course equips the students to understand and analyse the efficient operation and modern technologies in smart grids.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the evolution, global policies of smart grid, and analyse performance compared to conventional power grids. (Cognitive Knowledge Level: Understand)
CO 2	Analyse smart grid monitoring components and examine their functions, data analysis and system design considerations. (Cognitive Knowledge Level: Analyse)
CO 3	Analyse smart grid automation concepts, examine system architectures and control strategies, and apply in energy management and demand response methods. (Cognitive Knowledge Level: Apply)
CO 4	Understand communication technologies used in smart grids for monitoring and control. (Cognitive Knowledge Level: Understand)
CO 5	Understand power quality and cloud computing concepts in smart grids and analyse system architectures, devices, and cybersecurity threats. (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	1	1							1
CO 2	3	3	2	2							1
CO 3	3	3	3	2							2
CO 4	3	3	2	2							1
CO 5	3	3	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	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 (7 hours)

Introduction to Smart Grid

Smart grid - definitions, characteristics, functions, benefits, opportunities, components, concept of resilient and self-healing, clean development opportunities in smart grid, comparison of conventional grid and smart grid, smart grid reference architecture, recent smart grid developments and policies in India.

MODULE 2 (7 hours)

Smart Grid Monitoring Systems

Smart meters, smart sensors, intelligent electronic devices - circuit breakers monitor analysis, digital protective relay analysis, digital fault recorder assistant, information utilisation. Phasor measurement unit (PMU), wide area monitoring system (WAMS), automated meter reading (AMR), advanced metering infrastructure (AMI). Sensor and actuator networks (SANETs) - design considerations, SANETs in smart grid, actuators, challenges, applications.

MODULE 3 (7 hours)

Automation and Energy Management in Smart Grid

Smart substation, substation automation - basic approach, functional architecture, IEC 61850 substation - architecture, substation automation system. Feeder automation - field devices, communication networks, information management and control systems.

Energy management, demand response, demand side management(DSM) - methods, load shaping objectives, benefits, challenges, numerical problems.

MODULE 4 (8 hours)

Information and Communication Technology in Smart Grid

Introduction to local area network, home area network, neighbourhood area network, wide area network. Bluetooth - topology, architecture. Wireless mesh networks(WMN) - types, WMN protocol stack, Wifi (IEEE 802.11) technology. Worldwide interoperability for microwave access(WiMAX) - services, protocol stack, ZigBee network - topologies, protocol stack.

MODULE 5 (8 hours)

Power Quality and Cloud Computing in Smart Grid

Power quality management, operating conflicts in smart grid, power quality conditioners for smart grid - distribution static compensator, active power filters - shunt active power filters, series active power filters, unified power quality conditioner.

Cloud computing - private, public, hybrid, community, types of cloud computing services - Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS), Data as a Service (DaaS), cloud architecture of smart grid. Cyber Security smart grid – network security threats.

Case study of a smart grid pilot project (Assignments / Tutorial only)

Text Books

1. S. Chowdhury, S. P. Chowdhury, and P. Crossley, *Microgrids and Active Distribution Networks*, The Institution of Engineering and Technology (IET), 1st ed., 2009.
2. James A. Momoh, *Smart Grid: Fundamentals of Design and Analysis*, Wiley-IEEE Press, John Wiley & Sons, 2nd ed., 2012.
3. Radian Belu, *Smart Grid Fundamentals: Energy Generation, Transmission and Distribution*, CRC Press, Taylor & Francis Group, 1st ed., 2022.
4. Stuart Borlase, *Smart Grids Infrastructure, Technology and Solutions*, CRC Press Taylor & Francis Group, Pearson Education, 1st ed., 2013.
5. Janaka B. Ekanayake, Nick Jenkins, Kithsiri M. Liyanage, Jianzhong Wu, and Akihiko Yokoyama, *Smart Grid: Technology and Applications*, John Wiley & Sons , 1st ed., 2012.

Reference Books

1. G. Jegadeeswari, R. Elavarasi, S. Angaleswari, and B. Kirubadurai, *Distributed Energy and Smart Grids: Sustainable Energy for the Future*, Bentham Science Publishers, 1st ed., 2026.
2. Krishan Arora, Suman Lata Tripathi, Sanjeevikumar Padmanaban, *Smart Electrical Grid System: Design Principle, Modernization, and Techniques*, CRC Press, 1st ed., 2022.
3. Dileep G, *Smart Grid Components and Application*, Edberry's publications, 1st ed., 2019.
4. Haris M. Khalid and Abdalla Ismail Alzarooni, *Advanced Grid Technologies, Volume 1: Grid Evolution, Smart Grid Fundamentals, and Renewable Energy Integration*, Elsevier, 1st ed., 2025.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	37 Hours
	Module 1: Introduction to Smart Grid	7
1.1	Definitions need for smart grid, functions of smart grid, opportunities and benefits of smart grid	1
1.2	Concept of resilient and self- healing grid	1
1.3	Components and architecture	1
1.4	Clean development opportunities in smart grid	1
1.5	Difference between conventional grid and smart grid	1
1.6	Smart grid reference architecture	1
1.7	Present development and international policies of smart grid in India	1
	Module 2: Smart Grid Monitoring Systems	7
2.1	Introduction to smart meters, smart sensors	1
2.2	Intelligent electronic devices- circuit breakers monitor analysis, digital protective relay analysis, digital fault recorder assistant and information utilisation	1
2.3	Phasor measurement unit components, time synchronization techniques	1
2.4	Wide area monitoring system- architecture	1
2.5	Components of wide area monitoring system and applications	1
2.6	Automatic Meter Reading (AMR) System, services and functions, components of AMR systems	1
2.7	Advanced Metering Infrastructure (AMI)	1
	Module 3: Automation and Energy Management in Smart Grid	7
3.1	Smart substations, substation automation basic approach, functional architecture	1
3.2	IEC 61850 substation architecture and substation automation system	1
3.3	Feeder automation field devices	1
3.4	Feeder automation - communication networks, information management and control systems	1
3.5	Energy management demand response	1
3.6	Demand side management- methods, load shaping objectives, benefits, challenges	1
3.7	numerical problems	1
	Module 4: Information and Communication Technology in Smart Grid	8
4.1	Introduction to communication networks, local area network	1

4.2	Home area network	1
4.3	Neighbourhood area network	1
4.4	Wide area network	1
4.5	Bluetooth - topology, architecture	1
4.6	Wireless mesh networks- types, protocol stack, Wifi technology	1
4.7	Worldwide interoperability for microwave access - services, protocol stack	1
4.8	ZigBee network - topologies, protocol stack	1
	Module 5: Power Quality and Cloud Computing in Smart Grid	8
5.1	Power quality management, operating conflicts in smart grid	1
5.2	Power quality conditioners for smart grid - distribution static compensator	1
5.3	Active power filters - shunt active power filters	1
5.4	Series active power filters, unified power quality conditioner	1
5.5	Cloud computing - private, public, hybrid, community	1
5.6	Types of cloud computing services - Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS), Data as a Service (DaaS)	1
5.7	Cloud architecture of smart grid	1
5.8	Cyber Security smart grid – network security threats	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. What are the functions and opportunities of smart grid .
2. Explain the smart grid reference architecture.
3. Differentiate between conventional grid and smart grid.

Course Outcome 2 (CO 2)

1. What is the use of PMU in smart grid.
2. Explain the Wide Area Monitoring System with block diagram.
3. How automatic meter reading can make the system smarter.

Course Outcome 3 (CO 3)

1. Define feeder automation.
2. Discuss the role of IEC 61850 communication standard in smart substation.
3. Explain the concept of smart substation.

Course Outcome 4 (CO 4)

1. Explain the role of Neighbourhood Area Network (NAN) in smart grid technology.
2. Summarize Bluetooth based communication in a smart grid.
3. List the different topology of ZIGBEE.

Course Outcome 5 (CO 5)

1. Explain the different types of cloud computing services.
2. Explain the power quality issues in smart grid.
3. Explain the cloud architecture of smart grid.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

EIGHT SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2028

Course Code: : B24EE4P63

Course Name: : SMART GRID TECHNOLOGIES

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define smart grid concept and explain its necessity.
2. Explain the concept of resilient and self-healing grid.
3. Explain how automatic meter reading can make the system smarter.
4. Explain intelligent electronic devices.
5. Describe substation automation.
6. Explain energy management system.
7. Write a note on ZIGBEE.
8. Explain the role of Local Area Network (LAN) in smart grid technology.
9. Explain the necessity of cyber security in smart grid.
10. Write a note on power quality conditioners in smart grid.

PART B

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

11. With the help of block diagram explain the architecture of smart grid. What are the challenges of smart grid technology? (14 marks)

OR

12. Explain the recent smart grid developments and policies in India. (14 marks)
13. (a) What are the advantages of smart meters? (5 marks)
- (b) What are IEDs? What are their application in monitoring and protection. (9 marks)

OR

14. With the help of a neat block diagram explain the role of phasor measurement unit in smart grid. (14 marks)
15. Describe the architecture of smart substation and discuss the role of the IEC 61850 communication standard in smart substation. (14 marks)

OR

16. Explain the role of feeder automation in improving the reliability of smart grid. List the enabling components and elaborate their role in feeder automation. (14 marks)
17. Explain the role of LAN and HAN in smart grid. (14 marks)

OR

18. Explain the ZigBee network topologies and its protocol stack. (14 marks)
19. What are different types of cloud computing. Describe cloud architecture of smart grid. (14 marks)

OR

20. Describe the power quality issues of grid connected renewable energy source. Why is cyber security of prime importance in smart grid and how can it be achieved? (14 marks)

B24EE4P64	REAL TIME OPERATING SYSTEMS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The aim of the course is to impart the fundamental concepts of the operating systems widely used in embedded and real-time applications such as automotive control systems, medical devices, industrial automation, robotics, and aerospace systems. RTOS provide essential features like task scheduling, interrupt handling, inter-task communication, and resource management, allowing multiple tasks to run efficiently on a single processor. After the completion of course students will be able to design and implement RTOS based applications.

Prerequisites

Microprocessors and Microcontrollers

Course Outcomes

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

CO 1	Understand the functions and structure of general-purpose operating systems. (Cognitive Knowledge Level: Understand)
CO 2	Apply different scheduling algorithms on processes and threads. (Cognitive Knowledge Level: Apply)
CO 3	Understand a real time operating system memory management with its synchronization. (Cognitive Knowledge Level : Understand)
CO 4	Explain the task constraints and analyze the different scheduling algorithms on tasks. (Cognitive Knowledge Level: Understand)
CO 5	Analyze the applications of real time operating systems. (Cognitive Knowledge Level: Apply)

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	1	2				2
CO 2	3	3	3	2	2	1	2				2
CO 3	3	3	3	2	2	1	2				2
CO 4	3	2	3	2	2	1	2				2
CO 5	3	3	2	2	2	1	3				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/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 (8 hours)

Introduction to Real Time System

History of operating system, definition and types of real time systems - mainframe OS, server OS, multiprocessor OS, personal computer OS and embedded OS, hard vs soft real time systems.

RTOS Architectures

Monolithic systems, layered systems, microkernels, client server model.

MODULE 2 (8 hours)

Real Time Scheduling

Priority driven approach - fixed priority based and dynamic priority-based scheduling, weighted round-robin, multilevel queue and multilevel feedback queue scheduling, multiple processor scheduling - symmetric and asymmetric multiprocessing.

Thread

Thread control block and server threads, kernel level threads, multi-threading models.

MODULE 3 (7 hours)

Real Time Task Constraints

Task states and characteristics - periodic, aperiodic, sporadic, task scheduling algorithms- clock driven, event driven (EDD), EDF, rate monotonic and deadline monotonic, issues in using rate monotonic analysis in practical applications (basic concepts only), task synchronization- semaphore - types, real time kernel structure - non primitive and primitive kernel.

MODULE 4 (7 hours)

Memory Management in Operating Systems

Requirements for memory management - relocation, protection, sharing, logical organization, physical organization. memory partitioning - fixed and dynamic partitioning, virtual memory - swapping, paging, segmentation, security issues.

MODULE 5 (6 hours)

Commercial Real Time Operating Systems

Features of RTOS , UNIX as a real-time operating system - non-preemptive Kernel and dynamic priority levels, Windows as a real-time operating system - interrupt processing, support for resource sharing protocols, comparison between Windows NT and UNIX.

Popular Real Time Operating Systems

PSOS, VRTX, Vxworks, QNX, Micro C/OS-II , RT Linux, Lynx, Windows CE - features and application only.

Examples of Real Time Communication in Applications

Manufacturing automation, internet-based banking, internet telephony - basic concepts only.

Text Books

1. Abraham Silberschatz , *Operating System Concepts*, Wiley India, 10th ed., 2023.
2. Rajib Mall, *Real-Time Systems: Theory and Practice* , Iste/Hermes Science Pub., 1st ed., 2008.
3. Jane W. S. Liu , *Real - Time Systems*, Pearson Education India, 1st ed., 2002.
4. William Stallings, *Operating systems- Internals and design principles*, Prentice Hall, 9th ed., 2018.
5. Andrew S. Tanenbaum, Herbert Bos *Modern Operating Systems*, Pearson India, 5th ed., 2023.

Reference Books

1. Jean J Labrosse, *Micro C/OS-II, The Real Time Kernel*, CMP Books, 2nd ed., 2002.
2. Giorgio C. Buttazzo *Hard Real Time Computing Systems Predictable scheduling Algorithms and applications*, Course Technology Inc, Kluwer academic publishers, 4th ed., 2024.
3. David E. Simon *An Embedded Software Primer'* Pearson Education India, 1st ed., 2013.
4. Raj Kamal *Embedded Systems – Architecture, Programming and Design*, Tata McGraw Hill, 2nd ed., 2026.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Real Time System	8
1.1	History of operating system	1
1.2	Definition and types of real time systems - mainframe OS, server OS, multiprocessor OS	2
1.3	Personal computer OS and embedded OS	1
1.4	Hard Vs soft real time systems	1
	RTOS Architectures	
1.5	Monolithic systems,layered systems	2
1.6	Microkernels, client server model	1
	Module 2: Real Time Scheduling	8
2.1	Priority driven approach - fixed priority based and dynamic priority-based scheduling	2
2.2	Weighted round-robin	1
2.3	Multilevel queue and multilevel feedback queue scheduling	1
2.4	Multiple processor scheduling- symmetric and asymmetric multiprocessing	1
	Thread	
2.5	Thread control block and server threads	2
2.6	kernel level threads, multi-threading models	1
	Module 3:Real Time Task Constraints	7
3.1	Task states and characteristics- periodic, aperiodic, sporadic	1
3.2	Task scheduling algorithms - clock driven, event driven (EDD), EDF	2
3.3	Rate monotonic and deadline monotonic, issues in using rate monotonic analysis in practical applications (basic concepts only)	2
3.4	Task synchronization - semaphore - types	1
3.5	Real time kernel structure - non-primitive and primitive kernel	1
	Module 4: Memory Management in Operating Systems	7
4.1	Requirements for memory management - relocation, protection	1
4.2	Sharing, logical organization, physical organization	2
4.3	Memory partitioning- fixed and dynamic partitioning	2
4.4	Virtual memory- swapping, paging	1
4.5	Segmentation, security issues	1
	Module 5: Commercial Real Time Operating Systems	6

5.1	Features of RTOS, UNIX as a real-time operating system - non-preemptive Kernel and dynamic priority levels	1
5.2	Windows as a real-time operating system - interrupt processing, support for resource sharing protocols	1
5.3	Comparison between Windows NT and UNIX	1
	Popular Real Time Operating Systems	
5.4	PSOS, VRTX, Vxworks, QNX, Micro C/OS-II , RT Linux, Lynx, Windows CE - features and application only	2
	Examples of Real Time Communication in Applications	
5.5	Manufacturing automation, internet-based banking, internet telephony - basic concepts only	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Describe the monolithic RTOS architecture and provide one example.
2. Explain the layered system architecture and its advantages in real-time systems.
3. Define microkernel architecture and compare it with monolithic systems in terms of modularity.

Course Outcome 2 (CO 2)

1. Given a set of tasks with execution times and deadlines, apply fixed-priority scheduling to determine which task runs first.
2. Describe the concept of Thread Control Block (TCB) to initialize a new thread for a simple task and indicate what information is stored.
3. Compare multilevel queue and multilevel feedback queue in terms of handling interactive and batch tasks.

Course Outcome 3 (CO 3)

1. Compare clock-driven and event-driven scheduling in terms of predictability and flexibility.
2. Using the same tasks, apply Earliest Deadline First (EDF) scheduling and show the execution order.

3. Explain the difference between Rate Monotonic (RM) and Deadline Monotonic (DM) scheduling.

Course Outcome 4 (CO 4)

1. A process needs to be loaded at different memory locations. Which memory management requirement ensures it runs correctly? Justify your answer.
2. Define dynamic partitioning and explain how it reduces internal fragmentation.
3. Explain how paging helps in memory protection and sharing.

Course Outcome 5 (CO 5)

1. Describe dynamic priority levels in UNIX and how they affect real-time task execution.
2. Compare Windows NT and UNIX in terms of real-time performance, interrupt handling, and scheduling flexibility.
3. Describe internet-based banking as a real-time application and highlight timing requirements.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2028

Course Code: :B24EE4P64

Course Name: : REAL TIME OPERATING SYSTEMS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. List any three characteristics of real-time systems.
2. What is a personal computer operating system?
3. What is Weighted Round Robin scheduling?
4. State one difference between symmetric multiprocessing (SMP) and asymmetric multiprocessing (AMP)
5. What is a clock-driven scheduling algorithm?
6. What are the types of semaphore?
7. What is memory management in an operating system?
8. What is a page and a frame?
9. What is interrupt processing in Windows?
10. What is a non-preemptive kernel in UNIX?

PART B

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

11. Differentiate between hard real-time and soft real-time systems with suitable examples and diagrams. (14 marks)

OR

12. Explain different RTOS architectures: monolithic, layered, microkernel, and client-server model with neat diagrams. (14 marks)
13. (a) Explain server threads and their role in real-time systems. (7 marks)
(b) Describe kernel-level threads with advantages and disadvantages (7 marks)

OR

14. (a) Explain Weighted Round Robin scheduling with an example. (8 marks)
(b) Describe multilevel queue scheduling and its working. (6 marks)
15. (a) Explain different task states and characteristics in real-time systems. (6 marks)
(b) Describe periodic, aperiodic, and sporadic tasks with examples. (8 marks)

OR

16. (a) Explain the basic concepts of Rate Monotonic Analysis (RMA). (7 marks)
(b) Discuss the issues in using RMS in practical applications. (7 marks)
17. (a) What are security issues in memory management? (7 marks)
(b) Explain internal and external fragmentation with examples? (7 marks)

OR

18. (a) Compare fixed and dynamic partitioning. (7 marks)
(b) Describe swapping with advantages and disadvantages. (7 marks)
19. Discuss Micro C/OS-II, RT Linux, Lynx, and Windows CE with their features and applications. (14 marks)

OR

20. Explain how UNIX can be used as a real-time operating system. Discuss non-preemptive kernel and dynamic priority levels. (14 marks)

B24EE4P65	MICRO ELECTRO MECHANICAL SYSTEMS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course aims to equip students with practical and analytical skills in Micro Electro Mechanical Systems (MEMS) for real-world engineering applications. It conveys a comprehensive understanding of MEMS fundamentals, fabrication processes, material technologies and applications in emerging engineering domains. This course will enable the students to analyse, design and evaluate basic MEMS device.

Prerequisites

Introduction to Electrical Engineering, Electronics Circuits I

Course Outcomes

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

CO 1	Understand the operation of micro devices, micro systems and their applications. (Cognitive Knowledge Level: Understand)
CO 2	Apply electrostatic, thermal, and magnetic principles to design, analyze, and evaluate MEMS sensors and actuators for real-world applications. (Cognitive Knowledge Level: Apply)
CO 3	Understand the fundamental principles of piezoresistive and piezoelectric sensing and actuation. (Cognitive Knowledge Level: Understand)
CO 4	Apply micro-system fabrication and micromachining processes for MEMS-based applications. (Cognitive Knowledge Level: Apply)
CO 5	Apply polymer materials and microsystem packaging techniques, including bonding and sealing methods, to develop and assemble MEMS devices (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1		1				1		2
CO 2	3	3	3	2	2	1					2
CO 3	3	2	1		1						2
CO 4	3	3	3	3	3	2					2
CO 5	3	3	3	2	3	3	1	1	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/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 (8 hours)

Introduction to MEMS

Intrinsic Characteristics - miniaturization, microelectronics integration, parallel fabrication with precision, sensors and actuators - energy domains and transducers, sensor noise and design complexity. Microelectronics fabrication process flow, silicon based MEMS processes, new materials and fabrication processes - deposition and etching processes.

Electrical and Mechanical Concept

Conductivity of semiconductors, crystal planes and orientation, stress and strain, flexural beam bending analysis under simple loading conditions, torsional deflections.

MODULE 2 (8 hours)

Electrostatic Sensing and Actuation

Introduction, parallel-plate capacitors - working principle, applications - pressure sensor, flow sensor and parallel plate actuator, interdigitated finger capacitors - working principle - applications - inertia sensors and actuators.

Thermal Sensing and Actuation

Sensors and actuators based on thermal expansion, thermal couples, thermal resistors, application - inertia sensor.

Magnetic Actuation

Concepts, fabrication of micromagnetic components, case study

MODULE 3 (6 hours)

Piezoresistive Sensors

Sensor materials, stress analysis of mechanical elements - stress in flexural cantilevers, stress and deformation in membrane, applications.

Piezoelectric Sensing and Actuation

Introduction, properties, piezoelectric materials, applications - inertia, acoustic and flow sensors.

MODULE 4 (7 hours)

Micro System Fabrication

Photolithograph - ion implantation, diffusion-oxidation, chemical vapour deposition, etching.

Micro Manufacturing

Bulk micro manufacturing, surface micro machining, LIGA process –Micro stereo lithography.

Advanced Micro Electro Mechanical Systems

RF MEMS, BioMEMS, MOEMS, NEMS

MODULE 5 (7 hours)

Polymer MEMS

Polyimide, SU-8, liquid crystal polymer (LCP), PDMS, PMMA, parylene, fluorocarbon, applications-acceleration, pressure, flow, and tactile sensors.

Micro system Packaging

General considerations - Levels of micro system packaging, bonding techniques for MEMS - surface, anodic, silicon - on - insulator, wire bonding, sealing - assembly of micro systems.

Text Books

1. Chang Liu, *Foundations of MEMS*, Pearson Education Inc., 2nd ed., 2012
2. Tai Ran Hsu, *MEMS and Microsystems Design and Manufacture*, Tata McGraw Hill, 2nd ed., 2004
3. Stephen D Senturia, *Microsystem Design*, Springer Publication, 2nd ed., 2000.

Reference Books

1. James J. Allen, *Micro Electro Mechanical System Design*, CRC Press Publisher, 1st ed., 2005
2. Julian W Gardner, Vijay K. Varadan, Osama O. Awadelkarim, *Micro Sensors MEMS and Smart Devices*, John Wiley and Son LTD, 1st ed., 2013
3. Mohamed Gad-el-Hak, *The MEMS Handbook*, CRC press, 2nd edition, 2019

4. Nadim Maluf, *An Introduction to Micro Electro Mechanical System Design*, Artech House, 2nd ed., 2012
5. Thomas M. Adams and Richard A. Layton, *Introduction MEMS, Fabrication and Application*, Springer, 2nd ed., 2010.
6. Mark Madou, *Fundamentals of Micro fabrication*, CRC Press, 3rd ed., 2011.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to MEMS	8
1.1	Intrinsic characteristics - miniaturization, microelectronics Integration	1
1.2	Parallel fabrication with precision, sensors and actuators	1
1.3	Energy domains and transducers, sensor noise and design complexity	1
1.4	Microelectronics fabrication process flow, silicon based MEMS processes	1
1.5	New materials and fabrication processes - deposition and etching processes	1
	Electrical and Mechanical Concept	
1.6	Conductivity of semiconductors	1
1.7	Crystal planes and orientation, stress and strain	1
1.8	Flexural beam bending analysis under simple loading conditions, torsional deflections	1
	Module 2: Electrostatic Sensing and Actuation	8
2.1	Introduction, parallel-plate capacitors - working principle	1
2.2	Applications - pressure sensor, flow sensor and parallel plate actuator	1
2.3	Interdigitated finger capacitors - working principle	1
2.4	Applications - inertia sensors and actuators	1
	Thermal Sensing and Actuation	
2.5	Sensors and actuators based on thermal expansion, thermal couples	1
2.6	Thermal resistors, application - inertia sensor	1
2.7	Concepts, fabrication of micromagnetic components	1
2.8	Case study	1
	Module 3: Piezoresistive Sensors	6
3.1	Sensor materials, stress analysis of mechanical elements	1
3.2	Stress in flexural cantilevers	1
3.3	Stress and deformation in membrane, applications	1
	Piezoelectric Sensing and Actuation	
3.4	Introduction, properties	1

3.5	Piezoelectric materials	1
3.6	Applications - inertia, acoustic and flow sensors	1
	Module 4: Micro System fabrication	7
4.1	Photolithography - ion implantation	1
4.2	Diffusion - oxidation	1
4.3	Chemical vapour deposition-etching	1
	Micro manufacturing	
4.4	Bulk micro manufacturing	1
4.5	Surface micro machining	1
4.6	LIGA process - micro stereo lithography	1
	Advanced Micro Electro Mechanical Systems	
4.7	Overview of MEMS areas: RF MEMS, BioMEMS, MOEMS, NEMS	1
	Module 5: Polymer MEMS	7
5.1	Polyimide, SU-8, liquid crystal polymer (LCP)	1
5.2	PDMS, PMMA, parylene, fluorocarbon	1
5.3	Applications-acceleration sensors, pressure sensors	1
5.4	Flow sensors, and tactile sensors	1
	Micro system Packaging	
5.5	General considerations - levels of micro system packaging	1
5.6	Bonding techniques for MEMS - surface, anodic , silicon - on - insulator, wire bonding	1
5.7	Sealing - assembly of micro systems	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the intrinsic characteristics of MEMS such as miniaturization, integration, and precision fabrication.
2. Explain silicon-based processes, and discuss deposition and etching techniques used in fabrication.
3. Discuss conductivity of semiconductors, stress and strain, and analyze flexural beam bending and torsional deflection under simple loading conditions.

Course Outcome 2 (CO 2)

1. Apply the principles of electrostatic sensing and actuation to analyze the working of a parallel-plate capacitor.

2. Using thermal sensing principles, analyze the working of sensors based on thermal expansion, thermocouples, and thermal resistors.
3. Discuss the fabrication of micromagnetic components and evaluate their performance through a suitable case study.

Course Outcome 3 (CO 3)

1. Explain the working principle of piezoresistive sensors. Discuss suitable sensor materials and analyze stress distribution in a flexural cantilever used in MEMS.
2. Describe stress and deformation in a membrane structure. Explain how it is used in piezoresistive pressure sensing applications.
3. Discuss properties of piezoelectric materials and their applications in inertia, acoustic, and flow sensors.

Course Outcome 4 (CO 4)

1. Discuss the roles of ion implantation, diffusion, oxidation, and chemical vapour deposition in the process.
2. Analyze and compare bulk micromachining and surface micromachining techniques.
3. Explain different advanced MEMS technologies such as RF MEMS, BioMEMS, MOEMS, and NEMS.

Course Outcome 5 (CO 5)

1. Apply the properties of polymer materials such as Polyimide, SU-8, PDMS, and PMMA in the design of MEMS sensors.
2. Discuss how polymer MEMS materials are used in acceleration, pressure, flow, and tactile sensing applications.
3. Analyze the different levels of microsystem packaging and apply suitable bonding techniques for assembling a MEMS device.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2028

Course Code: B24EE4P65

Course Name: MICRO ELECTRO MECHANICAL SYSTEMS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What is miniaturization in MEMS?
2. Define fabrication process flow.
3. Give a brief description of electrostatic sensing and actuation.
4. Explain the concept of a thermal resistor.
5. What is stress in a flexural cantilever?
6. Mention any two applications of piezoelectric sensors.
7. Discuss the criteria for selecting materials for the masks used in etching.
8. List the steps involved in LIGA process.
9. State one application each of PDMS and PMMA in MEMS fabrication.
10. What are the levels involved in microsystem packaging?

PART B

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

11. (a) Describe various silicon-based MEMS fabrication processes. (7 marks)

- (b) Explain flexural beam bending under simple loading conditions with assumptions and equations. (7 marks)

OR

12. (a) Discuss parallel fabrication and how it improves manufacturing efficiency in MEMS. (7 marks)
(b) Illustrate crystal planes and crystal orientation in silicon with suitable diagrams. (7 marks)
13. (a) Describe the working principle of a parallel-plate capacitor. Explain its use in MEMS with suitable applications. (7 marks)
(b) Elaborate the materials and fabrication techniques used in micromachining. (7 marks)

OR

14. (a) Explain the construction and working principle of interdigitated finger capacitors. (7 marks)
(b) Describe the working principle of a thermocouple and its application in MEMS. (7 marks)
15. (a) Outline the working principle of piezoresistive sensors and describe how stress influences resistance. (7 marks)
(b) Describe the properties of piezoelectric materials and their importance in MEMS. (7 marks)

OR

16. (a) Explain deformation characteristics of a membrane under pressure with suitable equations. (7 marks)
(b) Illustrate the principle of acoustic sensing using piezoelectric materials. (7 marks)
17. (a) Discuss the photolithography process. State the chemicals used in each of the stages along with the operating conditions. (7 marks)
(b) Explain the challenges involved in BioMEMS. List three applications of BioMEMS. (7 marks)

OR

18. (a) Describe the various mechanical problems associated with surface micromachining. (6 marks)
(b) Elaborate any two applications of RF MEMS with diagrams. (8 marks)
19. (a) Explain the working principle of flow sensors in MEMS. (8 marks)
(b) Summarize the bonding techniques of Silicon-on Insulator and wire bonding with diagrams. (6 marks)

OR

20. (a) Describe the construction and working of MEMS pressure sensors. (6 marks)
(b) Explain the steps involved in assembly of micro systems. (8 marks)

B24EE4P66	SOFT COMPUTING TECHNIQUES	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4		

Preamble

This course introduces the core concepts of Soft Computing for developing intelligent systems. It covers neural networks, fuzzy logic, evolutionary computation, and machine learning techniques with emphasis on conceptual understanding and practical applications. The course equips students with problem-solving skills using biologically inspired and data-driven computational models.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the fundamental concepts of soft computing and artificial neural networks. (Cognitive Knowledge Level: Understand)
CO 2	Understand neural network architectures and apply learning algorithms to solve problems. (Cognitive Knowledge Level: Apply)
CO 3	Design fuzzy logic systems and fuzzy logic controllers. (Cognitive Knowledge Level: Understand)
CO 4	Apply genetic algorithms to solve optimization problems. (Cognitive Knowledge Level: Apply)
CO 5	Understand and apply machine learning algorithms for classification and clustering in real-world 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	3	1									1
CO 2	3	2	2		2						2
CO 3	3	3	3								1
CO 4	3	2	2	2	1						1
CO 5	3	3	1	2	3	1					3

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	20	20	20
Understand	60	40	40
Apply	20	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 (7 hours)

Introduction to Soft Computing and Neural Foundations

Soft and hard computing, evolution of soft computing, constituents of soft computing. Introduction to artificial neural networks, biological foundations of neural systems, basic ANN models, characteristics of artificial neural networks, activation functions. McCulloch–Pitts neuron model, simple perceptron, adaline, and madaline, learning concept in neural networks, realization of logic gates, limitations of single-layer models, the XOR problem.

MODULE 2 (8 hours)

Neural Network Architectures and Learning Paradigms

Neural network architectures - single layer, multilayer, and recurrent networks. Knowledge representation in neural networks, learning processes. Overview of supervised, unsupervised and reinforcement learning paradigms.

Learning Algorithms

Supervised learning algorithms - error-correction learning, backpropagation algorithm - representative case study. Unsupervised learning algorithms - Hebbian learning, competitive learning, Kohonen self-organizing maps.

MODULE 3 (8 hours)

Fuzzy Sets and Relations

Introduction to crisp sets and fuzzy sets - examples, properties. Basic operations on fuzzy sets. Fuzzy relations, cardinality of fuzzy relations, operations on fuzzy relations, properties. Membership functions - triangular, trapezoidal, Gaussian, and sigmoidal functions.

Fuzzy Logic Controllers

Structure of fuzzy logic controllers, block diagram. Processes of fuzzification, rule base formation, inference mechanism, and defuzzification. Defuzzification methods - max-membership principle, centroid method, weighted average method, mean of maxima, center of sums, center of largest area, and first and last of maxima.

MODULE 4 (7 hours)

Natural Evolution and Genetic Algorithm Basics

A brief overview - chromosomes, natural selection, crossover, mutation. Introduction to evolutionary computation and genetic algorithm (GA) concepts, basic genetic algorithm process - flowchart. Applications of genetic algorithms in engineering.

Genetic Algorithm Components and Applications

GA features - chromosomes, encoding schemes, fitness function, population, selection methods, crossover, mutation, elitism, convergence. Application of genetic algorithms for tuning fuzzy logic controllers.

MODULE 5 (7 hours)

Machine Learning

Introduction to machine learning (ML) - different approaches, applications, design perspective and issues in ML, supervised and unsupervised learning. Performance evaluation of machine learning models - training and testing data, accuracy, error rate, confusion matrix, precision, recall, F-measure, and basic model validation concepts.

ML Algorithms

Supervised learning algorithms - decision trees, k-nearest neighbors, applications. Unsupervised learning algorithms - k-means clustering and hierarchical clustering, applications.

Text Books

1. S.N.Sivanandam, S.N.Deepa, *Principles of Soft Computing*, Wiley India, 2007.
2. Simon Haykin, *Neural Networks a Comprehensive foundation*, Pearson Education, 1999.
3. Timothy J Ross, *Fuzzy logic with Engineering Applications*, McGraw Hill, New York.
4. George J. Klir, Bo Yuan, *Fuzzy Sets and Fuzzy Logic, Theory and Applications*, Prentice Hall of India, 2005.
5. Tom Mitchell, *Machine Learning*, McGraw Hill, 1997.

Reference Books

1. S.Rajasekharan, G.A.Vijayalakshmi Pai, *Neural Network, Fuzzy Logic and Genetic Algorithms Synthesis and Applications*, Prentice Hall India, 2003.
2. Bart Kosko, *Neural Network and Fuzzy Systems*, Prentice Hall of India,
3. W. Zurada J.M.s *Introduction to Artificial Neural Systems* ,Jaico Publishers, 2003.

4. Hassoun Mohammed H. *Fundamentals of Artificial Neural Networks*, Prentice Hall of India, 2002.
5. Driankov D., Hellendoorn H., Reinfrank M, *An Introduction to Fuzzy Control*, Narosa Publications, 1993.
6. D.E.Goldberg, *Genetic Algorithms in Search Optimisation and Machine Learning*, Pearson Education, 1989.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Soft Computing and ANN	7
1.1	Evolution of Soft Computing, constituents, and characteristics	1
1.2	Comparison between Hard and Soft Computing	1
1.3	Biological foundations and Artificial Neuron models	1
1.4	McCulloch–Pitts model, Perceptron, Adaline, and Madalines	2
1.5	Realization of logic gates and limitations of single-layer models	2
	Module 2: Neural Network Learning and Architectures	7
2.1	Network architectures: Feed-forward (Single/Multi-layer) and Recurrent	1
2.2	Learning paradigms: Supervised, Unsupervised, and Reinforcement	1
2.3	Learning rules: Hebbian, Perceptron, Delta, and Competitive learning	2
2.4	Backpropagation training: Algorithm and applications	2
2.5	Self-organizing maps and associative memory concepts	1
	Module 3: Fuzzy Logic Systems	8
3.1	Introduction to Fuzzy Sets and Relations; Membership functions	2
3.2	Fuzzy Logic Controller (FLC) architecture and block diagram	1
3.3	Fuzzification and Rule base formation	1
3.4	Inference mechanisms and Defuzzification methods (Centroid, MoM, etc.)	2
3.5	Simple fuzzy logic controllers with engineering examples	2
	Module 4: Genetic Algorithms (GA)	7
4.1	Natural evolution concepts: Chromosomes, selection, crossover, mutation	1

4.2	GA Basic Process: Flowchart and generational cycle	1
4.3	GA Components: Encoding schemes, Fitness function, Population, Elitism	2
4.4	Convergence and applications of GA in engineering optimization	2
4.5	Tuning Fuzzy Logic Controllers using Genetic Algorithms	1
	Module 5: Machine Learning (ML)	7
5.1	Introduction to ML: Approaches, design perspectives, and issues	1
5.2	Supervised learning: Decision Trees and K-Nearest Neighbors (k-NN)	2
5.3	Unsupervised learning: K-means and Hierarchical clustering	2
5.4	Performance evaluation: Accuracy, Confusion Matrix, Precision, Recall, F-measure	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Discuss the evolution of Soft Computing and how it differs from traditional Hard Computing in terms of precision and certainty.
2. List the core constituents of Soft Computing and explain their roles in developing intelligent systems.
3. Explain the architecture and learning limitations of the Adaline and Madaline models.

Course Outcome 2 (CO 2)

1. Describe the Hebbian learning rule and explain its application in pattern association tasks.
2. Illustrate the architecture of a Recurrent Neural Network (RNN) and discuss how it differs from a standard Feed-forward network.
3. Apply the Perceptron learning rule to find the weights for a simple linear classification problem given a small dataset.

Course Outcome 3 (CO 3)

1. Draw the functional block diagram of a Fuzzy Logic Controller and explain the role of each component from fuzzification to defuzzification.

2. Explain the concept of "Linguistic Variables" and "Fuzzy If-Then Rules" in representing human knowledge.
3. Describe the various defuzzification strategies, highlighting the "Center of Sums" and "Center of Largest Area" methods.

Course Outcome 4 (CO 4)

1. Illustrate the generational cycle of a Genetic Algorithm (GA) using a flowchart and explain the "Selection" process. the significance of each field.
2. Explain how Crossover and Mutation operators work together to balance exploration and exploitation in the search space.
3. Discuss the methodology for using a Genetic Algorithm to optimize the parameters of a Fuzzy Logic Controller.

Course Outcome 5 (CO 5)

1. Explain the working principle of the K-Nearest Neighbor (k-NN) algorithm and how the value of 'k' affects classification accuracy.
2. Differentiate between K-means clustering and Hierarchical clustering using a step-by-step algorithmic approach.
3. Given a Confusion Matrix for a 2-class problem, calculate the Accuracy, Precision, Recall, and F1-score of the model.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2028

Course Code: : B24EE4P66

Course Name: : SOFT COMPUTING TECHNIQUES

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the evolution of Soft Computing constituents.
2. What is a 'Simple Perceptron'? Mention its limitations.
3. Define Knowledge Representation in the context of Neural Networks.
4. What is 'Competitive Learning'?
5. List three properties of Fuzzy Relations.
6. Briefly explain the 'Mean of Maxima' defuzzification method.
7. Define 'Chromosome' and 'Gene' in Genetic Algorithms.
8. What is 'Crossover' in GA? List two types.
9. Differentiate between Supervised and Unsupervised Machine Learning.
10. What is a 'Confusion Matrix'?

PART B

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

11. (a) Distinguish between Hard Computing and Soft Computing. (7 marks)

- (b) Illustrate the McCulloch–Pitts neuron model and its use in realizing logic gates
(7 marks)

OR

12. Discuss the biological foundations of neurons and the various ANN characteristics
(14 marks)
13. (a) Explain the architecture of Single-layer and Multi-layer feed-forward networks.
(7 marks)
- (b) Describe the Reinforcement Learning paradigm and its applications. (7 marks)

OR

14. (a) Elaborate on the Error-correction learning process. (7 marks)
- (b) Explain the working principle of the Hebbian learning algorithm. (7 marks)
15. (a) Sketch and explain the block diagram of a Fuzzy Logic Controller. (7 marks)
- (b) Discuss the properties of Crisp sets versus Fuzzy sets with examples. (7 marks)

OR

16. Explain the various defuzzification methods including Center of Sums and Center of Largest Area.
(14 marks)
17. (a) Illustrate the basic Genetic Algorithm process using a detailed flowchart.
(7 marks)
- (b) Explain the different encoding schemes used in Genetic Algorithms. (7 marks)

OR

18. (a) Discuss the application of Genetic Algorithms in tuning Fuzzy Logic Controllers.
(7 marks)
- (b) Explain the concept of 'Selection Methods' and 'Fitness Function' in GA.
(7 marks)
19. (a) Describe the K-Nearest Neighbors (k-NN) algorithm for classification. (7 marks)
- (b) Explain K-means and Hierarchical clustering with their applications. (7 marks)

OR

20. (a) Define and explain the performance metrics: Accuracy, Precision, Recall, and F-measure.
(7 marks)
- (b) Discuss the design perspectives and common issues in Machine Learning
(7 marks)

The logo of Mar Athanasius College of Engineering is a large, faint watermark in the background. It features a circular gear-like border. Inside the circle is a light blue field containing a large orange cross. Below the cross is a green field. At the bottom of the circle is a pink field. Below the circle is a yellow banner with the text 'KNOWLEDGE IS POWER' in a serif font.

OPEN ELECTIVE III

B24EE4G31	INDUSTRIAL INSTRUMENTA- TION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The aim of this course is to provide students a strong foundation in the principles of sensors and transducers used to measure physical, thermal, and chemical variables in industrial environments. This course covers a diverse range of sensors for measuring mechanical movement, force, temperature, pressure, fluid properties like flow, density and specialized chemical pH analysis. On successful completion, students will be able to understand, select and apply appropriate instrumentation techniques for accurate measurement, monitoring, and control of industrial processes.

Prerequisites

NIL

Course Outcomes

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

CO 1	Understand the working principle of displacement and force measuring instruments. (Cognitive Knowledge Level: Understand)
CO 2	Illustrate the various types of temperature and pressure measurement techniques. (Cognitive Knowledge Level: Understand)
CO 3	Describe the working of various level and flow measurement instruments. (Cognitive Knowledge Level: Understand)
CO 4	Illustrate the various types of density and viscosity measuring instruments. (Cognitive Knowledge Level: Understand)
CO 5	Understand the principles and applications of special purpose industrial instrumentation systems.(Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	40	40	40
Understand	50	50	50
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/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 (7 hours)

Displacement Instrumentation

Potentiometers - wire wound and magneto resistance, differential transformers, differential inductance transducer, capacitive transducer, electro-optic encoder, rotational speed transducers-DC and AC tachogenerator.

Force and Allied Instrumentation

Principle of resistance strain gauge, load cell, piezo electric sensors, SG and LVDT based force transducers, tension sensing transducers, acceleration transducers, torque transducers.

MODULE 2 (7 hours)

Process Instrumentation I

Temperature measurement - resistance temperature detector(RTD), thermistors, semiconductor temperature sensors, ultrasonic thermometers, infra-red thermometry, thermal imaging.

Pressure instrumentation - bourdon tube and bellows, strain gauge based pressure sensors, capacitance type pressure transducers, low pressure instrumentation - pirani gauge, thermocouple gauge and ionization gauge.

MODULE 3 (8 hours)

Process Instrumentation II

Level measurement - level transducer with differential pressure sensing, capacitance based, displacement type, ultrasonic, and laser level sensors, microwave level switches, optical level detectors.

Flow measurement - differential pressure, magnetic, vortex, turbine, target, coriolis, and ultrasonic flowmeters, pitot tube.

MODULE 4 (7 hours)

Process Instrumentation III

Density measurement - displacement and float type, hydrometer, hydrostatic, radiation, vibrating, and gas densitometers.

Viscosity measurement - laboratory types - capillary tube, saybolt, automatic efflux-cup, rotational and falling ball viscometers, industrial types – differential pressure type continuous capillary, falling piston, and float viscometers.

MODULE 5 (7 hours)

Special Purpose Instrumentation

pH measurement - pH value, measurement of electrode potential, glass measurement electrode, reference electrode, ion-selective field effect transistors pH sensor. .

Humidity sensing - cellulose element, thin-film capacitance, and lithium chloride saturated salt dew-point sensor.

Gas sensors - ceramic, IR sensors, gas analysis, thermal conductivity measurement, interferometer.

Text Books

1. D.Patranabis, *Principles of Industrial Instrumentation*, Tata McGraw Hill Publishing Company Ltd., New Delhi, 3rd ed., 2017.
2. Tattamangalam R Padmanabhan, *Industrial Instrumentation-Principles and Design*, Springer, 3rd ed., 2009.
3. Ernest.O. Doebelin and Dhanesh.N. Manik, *Doebelin's Measurement Systems*, McGraw Hill Education, 6th ed., 2011.
4. Liptak B.G, *Instrumentation Engineers Handbook (Measurement)-vol I*, Chilton Book Co., 1994.
5. S. K. Singh, *Industrial Instrumentation and Control*, Tata McGraw Hill, 3rd ed., 2009.

Reference Books

1. Curtis D Johnson, *Process Control Instrumentation Technology*, Pearson, New York, 8th ed., 2005.
2. Robert B. Northrop, *Introduction to instrumentation and measurements*, CRC, Taylor and Francis, 3rd ed., 2018.
3. John G Webster, *Measurement, Instrumentation and Sensors Handbook*, CRC press, 1999.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Displacement, Force and Allied Instrumentation	7
1.1	Potentiometers - wire wound and magneto resistance	1
1.2	Differential transformers, differential inductance transducer	1

1.3	Capacitive transducer, electro-optic encoder	1
1.4	Rotational speed transducers - DC and AC tachogenerator	1
1.5	Principle of resistance strain gauge, load cell	1
1.6	Piezo electric sensors, SG and LVDT based force transducers, tension sensing transducers	1
1.7	Acceleration transducers, torque transducers	1
	Module 2:Process Instrumentation I	7
2.1	Resistance temperature detector (RTD)	1
2.2	Thermistors, semiconductor temperature sensors, ultrasonic thermometers	1
2.3	Infra red thermometry, thermal imaging	1
2.4	Pressure instrumentation - bourdon tube and bellows	1
2.5	Strain gauge-based pressure sensors, capacitance type pressure transducers	1
2.6	Low pressure instrumentation - Pirani gauge, thermocouple gauge and ionization gauge	2
	Module 3:Process Instrumentation II	8
3.1	Level measurement - level transducer with differential pressure sensing, capacitance-based level sensors	1
3.2	Displacement type, ultrasonic, and laser level sensors	1
3.3	Microwave level switches, optical level detectors	1
3.4	Differential pressure and magnetic type flowmeters	2
3.5	Vortex, turbine and target flowmeters	2
3.6	Coriolis and ultrasonic flowmeters, pitot tube	1
	Module 4: Process Instrumentation III	7
4.1	Density measurement - displacement and float type	1
4.2	Hydrometer, hydrostatic and radiation type	1
4.3	Vibrating, and gas densitometers	1
4.4	Viscosity measurement - laboratory types -capillary tube, say bolt and automatic efflux-cup type	1
4.5	Laboratory types - rotational and falling ball viscometers	1
4.6	Industrial types – differential pressure type continuous capillary	1
4.7	Industrial types – falling piston and float viscometers	1
	Module 5:Special Purpose Instrumentation	7
5.1	pH measurement - pH value, measurement of electrode potential, glass measurement electrode, reference electrode	1
5.2	Ion-selective field effect transistors pH sensor	1
5.3	Humidity sensing - cellulose element, thin-film capacitance, and lithium chloride saturated salt dew-point sensor	2
5.4	Gas sensors - ceramic, IR sensors	1
5.5	Gas analysis - thermal conductivity measurement, interferometer	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the working of a wire-wound potentiometer used for displacement measurement.
2. Differentiate between DC and AC tachogenerator used for rotational speed measurement.
3. Explain the principle of operation of a piezoelectric sensor.

Course Outcome 2 (CO 2)

1. Explain the working of a Resistance Temperature Detector (RTD).
2. Describe the concept and applications of thermal imaging in temperature measurement.
3. Explain the construction and working of a Bourdon tube pressure gauge.

Course Outcome 3 (CO 3)

1. Explain the construction and working of displacement type level transducers.
2. Describe the working principle of ultrasonic level sensors used for liquid level measurement.
3. Describe the operating principle of Coriolis flowmeters used for mass flow measurement.

Course Outcome 4 (CO 4)

1. Describe the construction and working of a hydrometer used for density measurement.
2. Describe the principle and working of gas densitometers used in industrial applications.
3. Explain the working of a falling ball viscometer used in laboratory viscosity measurements.

Course Outcome 5 (CO 5)

1. Explain the function of a reference electrode in pH measurement systems.
2. Describe the operating principle of thin-film capacitance humidity sensors.
3. Explain the construction of infrared (IR) gas sensors used in gas detection.

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: : B24EE4G31

Course Name: : INDUSTRIAL INSTRUMENTATION

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Differentiate between DC and AC tachogenerator used for rotational speed measurement.
2. Identify the limitations of LVDT based force sensing technique.
3. Explain the operating principle of semiconductor temperature sensors.
4. Illustrate how a strain gauge can be used for pressure measurement in industrial systems.
5. Explain the application of laser technology in level measurement.
6. What are the major components of a Coriolis flow meter. How can you determine the density of the fluid?
7. Discuss the practical considerations involved in designing a hydrostatic density sensor loop.
8. List out various applications of viscosity measurement.
9. Explain the function of the reference electrode in a pH measurement system.
10. What are the factors to be considered while operating ceramic gas sensors.

PART B

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

11. (a) Describe the construction and working of a magnetoresistance displacement sensor. (7 marks)
- (b) Classify the different types of strain gauge load cells used for force measurement and compare their performance. (7 marks)

OR

12. (a) With a neat sketch, explain the principle of an acceleration transducer. Also list its applications and limitations. (7 marks)
- (b) Explain the operation of a basic optic-encoder arrangement used for position measurement. (7 marks)
13. (a) Compare and contrast working of Bourdon tube and bellows type instruments used for pressure measurement with neat diagrams. List out its disadvantages. (8 marks)
- (b) Describe the method of ultrasonic thermometry used for temperature measurement. (6 marks)

OR

14. (a) Explain the working principle of RTDs and thermistors for temperature measurement. In a system where fast temperature response is required, determine whether a thermistor or RTD is more appropriate and explain why? (8 marks)
- (b) Illustrate the schematic diagram and equivalent circuit of a capacitance pressure transducer, and describe how it is used for differential pressure measurement. (6 marks)
15. (a) Explain the classification and working of capacitance-based level sensors based on conductivity of liquids. (8 marks)
- (b) With the help of a neat diagram illustrate the working of target flow meter. (6 marks)

OR

16. (a) A turbine flow meter is used for measuring liquid flow in a pipeline. Explain how the rotational speed is related to flow rate. (7 marks)
- (b) With the help of a diagram explain the working principle of optical level detectors. (7 marks)
17. (a) Differentiate between displacement and float type density measurement techniques. (7 marks)
- (b) A continuous viscosity measurement is required in an industrial pipeline. Suggest a suitable industrial viscometer and explain its working. (7 marks)

OR

18. (a) Explain the working of displacement type densitometer. What are its major drawback? (7 marks)
- (b) Illustrate the use of float viscometers for viscosity measurement in industrial systems. (7 marks)
19. (a) Explain the construction and working of lithium chloride saturated salt dew-point humidity sensors. (7 marks)
- (b) Discuss the operation of infrared (IR) based gas sensors used in gas detection. (7 marks)

OR

20. (a) Explain how interferometer can be used for gas analysis. (7 marks)
- (b) Ion-selective field effect transistor (ISFET) based pH sensors is most suitable for food applications. Justify the statement. (7 marks)

B24EE4G32	SUSTAINABLE ENERGY SYSTEMS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	2	3	2024

Preamble

The course aims to emphasize the need of transition from fossil fuel to renewable energy sources for addressing climatic change and environmental sustainability. The course covers the importance of renewable energy projects and necessity to mitigate global warming and biodiversity loss. Upon completing the course, students will be able to understand renewable energy technologies, methods to reduce environmental impacts and promoting sustainable development for a greener and more resilient future.

Prerequisites

Energy conversion and environmental sustainability (B24MC2T05)

Course Outcomes

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

CO 1	Understand sustainable development principles to evaluate energy systems and engineering solutions. (Cognitive Knowledge Level: Understand)
CO 2	Analyze conventional and non-conventional energy sources and calculating the carbon footprint of energy systems. (Cognitive Knowledge Level: Apply)
CO 3	Illustrate the principles and technologies involved in harnessing energy from various renewable energy sources. (Cognitive Knowledge Level: Understand)
CO 4	Analyze energy projects using economic and life-cycle assessment methods. (Cognitive Knowledge Level: Apply)
CO 5	Understand suitable techniques for energy recovery and conservation. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	1	2			3	1	1			2
CO 2	3	2	2	1	1	3	1	1	1		2
CO 3	3	1	2	1	1	3	1	1			2
CO 4	3	2	2	2	2	3	1	1	2	2	2
CO 5	3	1	1	1	1	3	1	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/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 (6 hours)

Introduction to Sustainable Energy

Sustainable principles - sustainable development, sustainability principles in practice, energy security, challenges for sustainable engineering. Key sustainability considerations - greenhouse gas emissions and climate change, carbon footprint, energy economic efficiency, cost of energy production, energy return on energy invested, cost of energy production, other costs of energy development.

MODULE 2 (8 hours)

Conventional to Nonconventional Energy Systems

Conventional energy- fossil fuels, coal, natural gas. Fossil fuels and pollution, coal and environmental regulations, oil supply and demand, environmental and societal risks, limitations, challenges and environmental impacts of conventional energy sources, conventional power plants- steam, diesel, gas turbine, nuclear power plants. Non-conventional energy, future of non-conventional energy, environmental and societal risk, concept of green energy, carbon credit, applications of green energy, calculation of carbon footprint.

MODULE 3 (8 hours)

Renewable Energy Technologies

Solar energy - photovoltaic (PV) systems, solar thermal system, solar collectors, solar heating, solar cooling, solar thermal power generation, solar energy potentials and challenges. Wind energy - wind turbines, wind resource assessment and site selection, wind power plants and their environmental impacts. Biomass energy - economics and technology, biomass energy potential and challenges. Ocean energy - offshore and shoreline wave energy converters, tidal energy converters. Geothermal energy - geothermal power plants.

MODULE 4 (7 hours)

Economics of Energy Generation and Conservation Systems

Unit cost of energy, payback period, time value of money, inflation, total life cycle costs, internal rate of return, capital recovery factor, present value method, levelized cost of energy, social and environmental costs, life cycle approach, greenhouse gas accounting, numerical problems.

MODULE 5 (7 hours)

Energy Sustainability

Energy conservation in transportation - hybrid electric vehicles, plug-in hybrid electric vehicles, petroleum requirement, carbon dioxide emissions. Energy conservation in agriculture - carbon emissions in agriculture. Energy use in buildings - energy efficiency in commercial buildings, energy efficiency in residential buildings. Energy audits and energy management, zero-energy urban districts, industrial energy consumptions, energy conservation in power generation, energy conservation in PV work, energy conservation by high-efficiency electric motors.

Text Books

1. Charles F Kutscher, Jana B Milford, Frank Kreith *Principles of Sustainable Energy Systems*, CRC Press; 3rd ed., 2021.
2. O. S. Miljanic and J. A. Pratt, *Introduction to Energy and Sustainability*, USA: Wiley, 1st ed., 2021.
3. F. M. Vanek, L. D. Albright, L. T. Angenent, M. W. Ellis and D. A. Dillard, *Energy Systems Engineering Evaluation and Implementation*, New York, NY, USA: McGraw-Hill, 4th ed., 2022.
4. D. J. C. Mackay, *Sustainable Energy – without the hot air*, UIT Cambridge, 1st ed., 2009.
5. G. D. Rai, *Non Conventional Energy Sources*, PHI Learning, 6th ed., 2022.

Reference Books

1. V. Nelson and K. Starcher, *Introduction to Renewable Energy*, Boca Raton, FL, USA: CRC Press, 2nd ed., 2016.
2. J. Cheng *Biomass to Renewable Energy Processes*, Boca Raton, FL, USA: CRC Press, 2nd ed., 2018.
3. M. Radovanovic, *Sustainable Energy Management: Planning, Implementation, Control and Security*, Burlington, MA, USA: Elsevier Academic Press, 2nd ed., 2023.
4. V. da Rosa, *Fundamentals of Renewable Energy Processes*, Burlington, MA, USA: Elsevier Academic Press, 2nd ed., 2009.
5. D Mukherjee and S Chakrabarti, *Fundamentals of Renewable Energy Systems*, New Age International Private Limited, 1st ed., 2004.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to Sustainable Energy	6
1.1	Sustainability principles- energy crisis, sustainable development, Sustainability Principles in Practice	2
1.2	Challenges for sustainability engineering	1
1.3	Energy economic efficiency, cost of energy production, energy efficiency and conservation	2
1.4	Energy return on energy invested, Cost of energy Production, other costs of energy development	1
	Module 2: Conventional to Nonconventional Energy Systems	8
2.1	Conventional energy- fossil fuels, coal, natural gas	1
2.2	Fossil fuels and pollution, coal and environmental regulations. Oil supply and demand, environmental and societal risks	1
2.3	Limitations, challenges and environmental impacts of conventional energy sources	1
2.4	Conventional power plants - steam, diesel, gas turbine, nuclear power plants	1
2.5	Non-conventional energy, environmental and societal risk	1
2.6	Concept of green energy, carbon credit	1
2.7	Applications of green energy, calculation of carbon footprint	2
	Module 3: Renewable Energy Technologies	8
3.1	Solar energy - photovoltaic (PV) systems, solar thermal system	1
3.2	Solar collectors, solar heating, solar cooling, solar thermal power generation, solar energy potentials and challenges	2
3.3	Wind energy-wind turbines, wind resource assessment and site selection, wind power plants and their environmental impacts	1
3.4	Biomass energy - economics and technology, biomass energy potential and challenges	1
3.5	Ocean energy - offshore and shoreline wave energy converters	1
3.6	Tidal energy converters	1
3.7	Geothermal energy - geothermal power plants	1
	Module 4: Economics of Energy Generation and Conservation Systems	7

4.1	Unit cost of energy, payback period, time value of money, inflation, total life cycle costs	2
4.2	Internal rate of return, capital recovery factor, present value method	1
4.3	Levelized cost of energy, social and environmental costs	1
4.4	Life cycle approach, greenhouse gas accounting	1
4.5	Numerical problems	2
	Module 5: Energy Sustainability	7
5.1	Energy conservation in transportation	2
5.2	Energy conservation in agriculture - carbon emissions in agriculture	1
5.3	Energy use in buildings	2
5.4	Energy audits and energy management, zero-energy urban districts, industrial energy consumptions, energy conservation in power generation	1
5.5	Energy conservation in PV work, energy conservation by high-efficiency electric motors	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain sustainability principles.
2. What is carbon credit.
3. Discuss the need for energy return in sustainable development.

Course Outcome 2 (CO 2)

1. Evaluate technical and economic feasibility of renewable energy systems and their environmental impacts.
2. Problems on carbon foot print.
3. Applications of green energy.

Course Outcome 3 (CO 3)

1. Explain solar collectors and solar heaters.
2. Explain wind turbine aerodynamics.
3. Define solar photovoltaic and solar thermal systems.

Course Outcome 4 (CO 4)

1. State the need for economic analysis of energy projects.
2. Define payback period.
3. Illustrate how life cycle costing approach can be used for comparing energy projects.

Course Outcome 5 (CO 5)

1. What are the energy conservation opportunities industrial applications.
2. Define energy management.
3. State the need for energy audit.

MODEL QUESTION PAPER

QP CODE:

Pages: 3

Reg.No.:

Name:

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

EIGHT SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2028

Course Code: : : B24EE4G32

Course Name: : SUSTAINABLE ENERGY SYSTEMS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define sustainable development and explain how it relates to energy security .
2. What is meant by energy return on energy invested. Briefly discuss its significance in sustainable energy systems.
3. Explain the concept of green energy with applications.
4. What is carbon credit and how it influences the sustainable energy systems.
5. Define solar photovoltaic and solar thermal systems. Briefly state one major difference between them in terms of energy conversion.
6. Evaluate the economic feasibility of a 20 MW wind farm compared with an equivalent solar PV plant.
7. What are the advantages and disadvantages of pay back period method?
8. What do you mean by time value of money?
9. Explain what do you mean by energy audit report.
10. Explain how energy efficient motors helps in reducing energy consumption.

PART B

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

11. (a) Analyze the challenges for sustainable engineering in balancing energy security with the cost of energy production and other development costs. (8 marks)
(b) Discuss the relation between energy and sustainable development (6 marks)

OR

12. Discuss the key sustainability principles that guide sustainable energy practices. Evaluate how carbon foot print and climatic changes influence sustainable energy systems. (14 marks)
13. A green energy project that integrate solar photovoltaic and solar thermal systems. Describe the methods to calculate the carbon footprint of a solar energy installation over its life cycle also compute the carbon footprint reduction achieved by replacing a 50MW coal plant with an equivalent solar PV plant. (14 marks)

OR

14. Discuss the limitations, challenges and environmental effects of conventional energy sources and compare with non-conventional energy options. (14 marks)
15. (a) Explain the steps involved in wind resource assessment and site selection. (6 marks)
(b) Discuss the environment impacts of wind turbines and mitigation measures to minimize them . (8 marks)

OR

16. Describe the technological processes used in biomass energy conversion and analyze the economic and technological challenges associated with biomass utilization. (14 marks)
17. (a) Calculate the energy saving and payback period which can be achieved by replacing a 11 kW, existing motor with an EEM. The capital investment required for EEM is Rs. 40,000/-. Cost of energy/kWh is Rs. 5. The loading is 70% of the rated value for both motors. Efficiency of the existing motor is 81% and that of EEM is 84.7%. (8 marks)
(b) Compare internal rate of return method with present value method for the selection of energy projects. (6 marks)

OR

18. (a) An investment of Rs. 1.10 Lakh is made for a variable speed drive at the beginning of the year, which is also the date of first operation. Savings expected over 4 years are Rs. 28,000, Rs. 35,000, Rs. 40,000 and Rs. 40,000 respectively. Find out the internal rate of return of the project. (8 marks)
(b) How will you assess the financial feasibility of a project using average rate of return method? (6 marks)

19. (a) Explain the methodology used in detailed energy auditing. (8 marks)
(b) Explain the energy conservation in photovoltaic work (6 marks)

OR

20. Describe energy conservation methods in zero energy urban districts and high efficiency electric motors. (14 marks)



B24EE4G33	HUMAN FACTORS ENGINEERING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4		

Preamble

The course aims to integrate human considerations into the design of work systems, tools, machines, and environments to enhance safety, comfort, efficiency, and productivity. The course covers anthropometry, physiology, biomechanics, workstation design, and environmental factors such as visual, thermal, auditory, and shift work conditions. The course equips students with ergonomic principles and analytical tools applicable to industrial and organizational contexts.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the basic principles of human factors and ergonomics ,man-machine systems, including human information processing, perception, attention, and mental workload. (Cognitive Knowledge Level: Understand)
CO 2	Understand the principles of visual, auditory, tactual, and speech displays , basic design guidelines for effective human communication and information presentation. (Cognitive Knowledge Level: Understand)
CO 3	Analyze manual handling tasks, apply NIOSH lifting guidelines, and use anthropometric data to design safe, efficient, and ergonomically sound workspaces and work systems. (Cognitive Knowledge Level: Apply)
CO 4	Evaluate shift work and work-rest schedules, apply anthropometric data in workplace design, and implement ergonomic principles to create safe and effective work environments with appropriate lighting and visual conditions. (Cognitive Knowledge Level: Apply)
CO 5	Identify visual, auditory,thermal, and vibration factors in work environments and apply ergonomic principles to improve comfort, safety, and performance. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	50	40	40
Understand	50	40	40
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/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 (7 hours)

Human Factors and Ergonomics

Introduction to human factors and ergonomics- systems description, nature of man-machine systems and characteristics, design of cognitive work-information theory, human information processing model, information input and processing, perception, attention, mental workload.

MODULE 2 (7 hours)

Information input

Display of visual information-types of information presented by displays, signal and warning lights, representational displays, head up displays, display of auditory information - specific design principles, relative discrimination of auditory signals, tactual and olfactory displays, cutaneous senses, speech communication-components of speech communication systems.

MODULE 3 (8 hours)

Manual Work and Design Guidelines

Energy expenditure, heart rate, NIOSH lifting guidelines – multitask lifting guidelines.

Engineering Anthropometry and Work-Space Design

Statistical basis of anthropometry-use of anthropometric data in design, principles of work design, design of work surfaces, science of seating, cumulative trauma disorders, fundamental risk factors and prevention.

MODULE 4 (7 hours)

Shift Work and Working Hours

Work rest scheduling, experiment on designing a workplace using the anthropometric data collected.

Work Environment Design

Visual ergonomic - environment components in work systems, ergonomic design framework for environment, illuminance, luminance and contrast measurement, contrast measures in work situations, glare and inspection lighting.

MODULE 5 (7 hours)

Thermal and Vibration Environment

Heat stress problems and thermal regulation, thermal balance and heat stress, thermal environment evaluation, whole-body vibration and discomfort.

Auditory Environment

Auditory environment and performance, noise exposure and hearing loss, noise effects on performance, ergonomic design auditory environments.

Text Books

1. M. S. Sanders and E. J. McCormick, *Human Factors in Engineering Design*, McGraw Hill Education, 7th ed., 1993
2. M. R. Lehto, S. J. Landry, and J. Buck, *Introduction to Human Factors and Ergonomics for Engineers*, Boca Raton, FL: CRC Press, 4th ed., 2026.
3. C. D. Wickens, J. G. Hollands, S. Banbury, and R. Parasuraman, *Engineering Psychology and Human Performance*, New York, NY, USA: Routledge, 4th ed., 2015

Reference Books

1. D. A. Norman, *The Design of Everyday Things*, Basic Books, 9th ed., 2013
2. G. Salvendy, *Handbook of Human Factors and Ergonomics*, Hoboken, NJ, USA: Wiley,, 4th ed., 2012
3. R. S. Bridger, *Introduction to Ergonomics*, CRC Press, 3rd ed., 2009.
4. M. Helander, *A Guide to the Ergonomics of Manufacturing*, CRC Press, 2nd ed., 1997

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Human Factors and Ergonomics	7
1.1	Introduction to human factors and ergonomics	1
1.2	Systems description, nature of man-machine systems and characteristics	1

1.3	Design of cognitive work-information theory, human information processing model	2
1.4	Information input and processing	1
1.5	Perception, attention, mental workload	2
	Module 2:Information input	7
2.1	Display of visual information-types of information presented by displays	1
2.2	Signal and warning lights, representational displays, head up displays	1
2.3	Display of auditory information - specific design principles, relative discrimination of auditory signals	2
2.4	Tactual and olfactory displays	2
2.5	Cutaneous senses, speech communication-components of speech communication systems	1
	Module 3:Manual Work and Design Guidelines, Engineering Anthropometry and Work-Space Design	8
3.1	Energy expenditure, heart rate, NIOSH lifting guidelines – multitask lifting guidelines	2
3.2	Statistical basis of anthropometry-use of anthropometric data in design	1
3.3	Principles of work design	1
3.4	Design of work surfaces, science of seating	2
3.5	Cumulative trauma disorders, fundamental risk factors and prevention	2
	Module 4:Shift Work and Working Hours, Work Environment Design	7
4.1	Work rest scheduling, experiment on designing a workplace using the anthropometric data collected	2
4.2	Visual ergonomic - environment components in work systems	1
4.3	Ergonomic design framework for environment	1
4.4	Illuminance, luminance and contrast measurement	1
4.5	Contrast measures in work situations	1
4.6	Glare and inspection lighting	1
	Module 5:Thermal and Vibration Environment, Auditory Environment	7
5.1	Heat stress problems and thermal regulation, thermal balance and heat stress	2
5.2	Thermal environment evaluation, whole-body vibration and discomfort	2
5.3	Auditory environment and performance	1
5.4	Noise exposure and hearing loss, noise effects on performance	1
5.5	Ergonomic design of auditory environments	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the nature and characteristics of man-machine systems.
2. Describe the human information processing model.
3. Discuss the role of perception and attention in human performance.

Course Outcome 2 (CO 2)

1. Explain representational displays and their applications.
2. Describe the design principles for auditory displays.
3. Discuss the types and design principles of visual displays in ergonomics.

Course Outcome 3 (CO 3)

1. Explain energy expenditure and heart rate as measures of workload.
2. Discuss the NIOSH lifting guidelines for safe lifting.
3. Explain the principles of work surface design.

Course Outcome 4 (CO 4)

1. Explain shift work and its impact on human performance.
2. Describe illuminance, luminance and contrast measurement.
3. Explain glare and inspection lighting in workplaces.

Course Outcome 5 (CO 5)

1. Discuss thermal balance and heat stress evaluation.
2. Explain measures to reduce vibration exposure.
3. Describe methods of noise control in workplaces.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2028

Course Code: : B24EE4G33

Course Name: : HUMAN FACTORS ENGINEERING

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain mental workload and its effects on task performance.
2. Describe the components of a man-machine system.
3. Explain the design principles of visual displays.
4. Discuss signal and warning lights in human-machine systems.
5. List the fundamental risk factors for CTD.
6. Describe the use of anthropometric data in engineering design.
7. Discuss work-rest scheduling in industrial tasks.
8. Explain the ergonomic design framework for environmental conditions.
9. Describe the sources of vibration in workplaces.
10. Explain the concept of auditory masking.

PART B

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

11. Discuss human factors engineering and its importance in system design. (14 marks)

OR

12. Describe the design of cognitive work systems based on information processing principles. (14 marks)

13. Explain the display of auditory information and discrimination of auditory signals. (14 marks)

OR

14. Describe visual, auditory, tactual and olfactory displays in human-machine systems. (14 marks)

15. (a) Discuss the fundamental principles and ergonomic considerations in the design of work surfaces, highlighting their impact on efficiency, safety, and user comfort. (8 marks)

(b) Explain the role of ergonomics in reducing physical workload and fatigue. (6 marks)

OR

16. Describe cumulative trauma disorders, their causes, and prevention methods. (14 marks)

17. Discuss the design of a workplace using anthropometric data. (14 marks)

OR

18. Explain the visual ergonomic principles used in work environment design. (14 marks)

19. Explain the factors affecting thermal comfort and workplace design. (14 marks)

OR

20. Explain the methods for measuring and evaluating workplace noise levels. (14 marks)

B24EE4G34	ELECTRICITY MARKETS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The course aims to understand the principles and working of restructured power systems and electricity markets around the world. The course conveys the principles and applications of electricity markets, covering fundamentals of deregulation, market structures, and pricing mechanisms. The course will enable the students to design, evaluate, and apply electricity market mechanisms, select suitable pricing and hedging strategies and critically assess global and local energy market practices for efficient and sustainable power system operation.

Prerequisites

NIL

Course Outcomes

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

CO 1	Understand the structure and operation of electrical energy markets, including trading mechanisms and ancillary services. (Cognitive Knowledge Level: Understand)
CO 2	Understand the economic principles to assess electricity market deregulation and participation strategies of consumers, producers, low marginal cost plants, and hybrid entities. (Cognitive Knowledge Level: Understand)
CO 3	Apply electricity market pricing concepts to determine market equilibrium, prices, congestion, losses, and reserves (Cognitive Knowledge Level: Understand)
CO 4	Understand the the evolution of electricity markets in US, Europe, and India, including reforms, trading mechanisms, and risk-hedging instruments. (Cognitive Knowledge Level: Apply)
CO 5	Apply local energy market concepts to develop business models and revenue strategies for rooftop solar PV and microgrids. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2			1	2			1	2	1
CO 2	3	3	1		1	2			1	3	1
CO 3	3	3	2	1	2	1				3	1
CO 4	2	2		1	1	2	1		1	2	2
CO 5	3	3	3	1	2	3	1	1	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	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 (8 hours)

Markets for Electrical Energy

Market structure and architecture: Spot market - day ahead market - real time market – reserve market, need for a managed spot market, open electrical energy markets -bilateral trading, electricity pools, comparison of pool and bilateral trading, ancillary services - obtaining ancillary services, buying ancillary services, selling ancillary services.

MODULE 2 (8 hours)

Electricity Market Structures

Models of competition- monopoly, purchasing agency, wholesale competition, retail competition, conditions for deregulation, pricing power, energy, and capacity, power supply and demand, marginal cost.

Participating in Markets for Electrical Energy

Consumer's perspective, producer's perspective, perspective of plants with very low marginal costs, the hybrid participant's perspective.

MODULE 3 (7 hours)

Electricity Pricing

Concept of marginal cost, market equilibrium, market clearing price, congestion pricing fundamentals, locational marginal pricing, operating reserve pricing, value-of-lost-load pricing, pricing losses on lines, pricing losses at nodes.

MODULE 4 (7 hours)

Markets Around the World

US and European market evolution, reforms in Indian power sector, power exchanges, power purchase agreements, current trends and future scope of electricity markets.

Derivative Markets

Hedging risk – contract for difference , forwards, futures, options, swaps

MODULE 5 (6 hours)

Local Energy Markets

Virtual power plant and microgrids, microgrid prosumer consortium, role of Distribution System Operator (DSO), business models, revenue generation from roof-top solar PV, net and gross feed-in-tariff.

Text Books

1. Steven Stoft, '*Power System Economics: Designing Markets for Electricity*', Wiley-IEEE Press, 2002.
2. Daniel S. Kirschen, Goran Strbac, '*Fundamentals of Power System Economics*', Wiley, 2018.
3. Mohammad Shahidehpour, Muwaffaq Alomoush, '*Restructured Electrical Power Systems: Operation: Trading, and Volatility*', Marcel Dekker Inc., 2001.

Reference Books

1. Mohammad Shahidehpour, Hatim Yamin, Zuyi Li, '*Market Operations in Electric Power Systems: Forecasting, Scheduling, and Risk Management*', IEEE Press, 2002.
2. Andreas Sumper, '*Micro and Local Power Markets*', John Wiley and Sons Ltd, 2019
3. Deqiang Gan, Donghan Feng, Jun Xie '*Electricity Markets and Power System Economics*' CRC Press Taylor and Francis Group, 2014
4. Indian Energy Exchange: <http://www.iexindia.com>
5. Power Exchange India Limited: <http://www.powerexindia.com>
6. Indian Electricity Regulations: <http://www.cercind.gov.in>

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Markets for Electrical Energy	8
1.1	Market structure and architecture- spot market	1
1.2	Day ahead market, real time market	1
1.3	Reserve market, need for a managed spot market	1
1.4	Open electrical energy markets -bilateral trading	1

1.5	Electricity pools	1
1.6	Comparison of pool and bilateral trading	1
1.7	Ancillary services - obtaining ancillary services	1
1.8	Buying ancillary services, selling ancillary services	1
	Module 2: Electricity Market Structures	8
2.1	Models of competition- monopoly, purchasing agency	1
2.2	Wholesale competition, retail competition	1
2.3	Conditions for deregulation, pricing power	1
2.4	Energy and capacity, power supply and demand	1
2.5	Marginal cost	1
	Participating in Markets for Electrical Energy	
2.6	Consumer's perspective, producer's perspective	1
2.7	Perspective of plants with very low marginal costs	1
2.8	Hybrid participant's perspective	1
	Module 3: Electricity Pricing	7
3.1	Concept of marginal cost, market equilibrium	1
3.2	Market clearing price	1
3.3	Congestion pricing fundamentals	1
3.4	Locational marginal pricing	1
3.5	Operating reserve pricing	1
3.6	Value-of-lost-load pricing	1
3.7	Pricing losses on lines, pricing losses at nodes	1
	Module 4: Markets Around the World	7
4.1	US and European market evolution	1
4.2	Reforms in Indian power sector, power exchanges	1
4.3	Power purchase agreements	1
4.4	Current trends and future scope of electricity markets	1
	Derivative Markets	
4.5	Hedging risk – contract for difference	1
4.6	Forwards, futures, options, swaps	2
	Module 5: Local Energy Markets	6
5.1	Virtual power plant and microgrids	1
5.2	Microgrid prosumer consortium	1
5.3	Role of Distribution System Operator (DSO)	1
5.4	Business models, Revenue generation from roof-top solar PV	2
5.5	Net and gross feed-in-tariff.	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Explain the structure and architecture of electrical energy markets, including spot, day-ahead, real-time, and reserve markets.

2. Compare bilateral trading and electricity pool markets, highlighting their operation and key differences.
3. Explain the concept of ancillary services and describe how they are obtained, bought, and sold in electricity markets.

Course Outcome 2 (CO 2)

1. Explain different electricity market structures (monopoly, purchasing agency, wholesale and retail competition) and the conditions required for deregulation.
2. Explain the concepts of marginal cost, supply-demand relationship, and pricing power in electricity markets.
3. Describe the participation strategies in electricity markets from the perspectives of consumers, producers, low marginal cost plants, and hybrid entities.

Course Outcome 3 (CO 3)

1. Explain how marginal cost and demand determine market equilibrium and market clearing price in electricity markets.
2. Explain the concepts of congestion pricing and locational marginal pricing, and how they influence electricity prices.
3. Describe operating reserve pricing, value-of-lost-load (VoLL), and methods of pricing transmission losses on lines and at nodes.

Course Outcome 4 (CO 4)

1. Explain the evolution of electricity markets in the US, Europe, and India, highlighting key reforms and developments.
2. Describe the role of power exchanges and power purchase agreements (PPAs) in electricity trading mechanisms.
3. Explain different risk-hedging instruments used in electricity markets, such as contracts for difference, forwards, futures, options, and swaps.

Course Outcome 5 (CO 5)

1. Apply the concepts of microgrids and virtual power plants to design a suitable local energy market model for efficient energy management.
2. Develop a business model for a microgrid prosumer consortium, considering the role of the Distribution System Operator (DSO).
3. Apply net and gross feed-in tariff mechanisms to evaluate revenue generation from a rooftop solar PV system.

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2028

Course Code : B24EE4G34

Course Name : ELECTRICITY MARKETS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Differentiate between day-ahead market and real-time market.
2. Give a brief explanation of an electricity pool.
3. What is a monopoly model in electricity markets?
4. State any two features of wholesale electricity markets.
5. Define market clearing price.
6. What is meant by pricing losses on transmission lines?
7. Mention any two features of US electricity markets.
8. Define power exchange.
9. Explain the concept of a virtual power plant (VPP).
10. What is meant by the term microgrid in modern power systems?

PART B

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

11. (a) Describe the working of: i) Spot market ii) Day-ahead market iii) Real-time market. (7 marks)

- (b) Discuss open electrical energy markets and explain bilateral trading in detail. (7 marks)

OR

12. (a) Describe the procedures involved in buying and selling ancillary services. (7 marks)
(b) How do reserve markets contribute to the reliability of the electrical grid? (7 marks)
13. (a) Discuss the conditions necessary for deregulation of electricity markets. (7 marks)
(b) Explain the producer's perspective in electrical energy markets. (7 marks)

OR

14. (a) What do you understand by pricing power, and what are its implications in power markets? (7 marks)
(b) Describe the role and behavior of plants with very low marginal costs in electricity markets. (7 marks)
15. (a) Explain the concept of locational marginal pricing (LMP) with suitable justification of its significance in electricity markets. (7 marks)
(b) Discuss the concept of value-of-lost-load and its application in electricity pricing. (7 marks)

OR

16. (a) Explain congestion pricing fundamentals with suitable examples. (7 marks)
(b) Describe operating reserve pricing and discuss its significance in reliable power system operation. (7 marks)
17. (a) Outline the key reforms in the Indian power sector and analyze their impact. (7 marks)
(b) Discuss various methods of hedging risk in electricity markets. (7 marks)

OR

18. (a) Describe Power Purchase Agreements and their importance in electricity markets. (7 marks)
(b) Explain contract for difference with suitable example. (7 marks)
19. (a) Discuss the concept of a microgrid prosumer consortium and its benefits. (7 marks)
(b) Compare net feed-in tariff and gross feed-in tariff with suitable examples. (7 marks)

OR

20. (a) Explain the role and responsibilities of the Distribution System Operator (DSO) in local energy markets. (7 marks)
(b) Describe the different revenue earning opportunities from rooftop solar power systems. (7 marks)

B24EE4G35	INTERNET OF THINGS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course provides students with a comprehensive understanding of the concepts, components, and technologies underlying the Internet of Things. The topics covered include IoT fundamentals, sensors and actuators, embedded prototyping platforms, connectivity and communication technologies, and representative IoT applications. The course will enable students to understand IoT system requirements, select appropriate devices and communication technologies, and apply IoT solutions to real-world domains.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain IoT concepts, characteristics, architectural models, and enabling technologies, and distinguish IoT from related paradigms such as M2M, cyber-physical systems, and web of things. (Cognitive Knowledge Level: Understand)
CO 2	Understand the characteristics and selection of sensors and actuators, and describe basic embedded systems and prototyping platforms for IoT. (Cognitive Knowledge Level: Understand)
CO 3	Explain IoT connectivity technologies to select suitable communication methods for IoT applications. (Cognitive Knowledge Level: Understand)
CO 4	Apply various communication protocols and cloud-fog models to develop scalable IoT solutions. (Cognitive Knowledge Level: Apply)
CO 5	Apply IoT technologies to analyze real-world applications in agriculture, health-care, energy, and industry. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	40	20	20
Understand	60	40	40
Apply		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 (6 hours)

Introduction to IoT

Definition and characteristics of IoT, architectural view, major components and technologies in IoT systems – hardware, software, communication, APIs. IoT vs M2M, cyber physical systems, web of things – features and differences. Success factors of IoT.

MODULE 2 (7 hours)

Sensors, Actuators and Prototyping Basics

Sensors and sensing - characteristics, types, considerations. Actuators - types, characteristics, comparison. Embedded computing basics - software, integrated development environment, hardware units. Microcontroller based platforms for embedded prototyping- examples, features and comparison.

MODULE 3 (8 hours)

Connectivity Technologies for IoT

Wireless connectivity - RFID, NFC, Zigbee, Bluetooth/Bluetooth LE, Wifi (IEEE 802.11), cellular technology - GSM, 3G, 4GLTE, LoRa technology - LoRaWAN, Narrow Band (NB-IoT), Sigfox. (overview, features, applications, limitations.)

Wired connectivity - UART / USART serial communication, serial peripheral interface, I2C Bus, wired USB, ethernet.

MODULE 4 (9 hours)

IoT Communication Technologies

Concept of constrained networks and low power and lossy networks (LLNs), infrastructure protocols - IPv4, IPv6, RPL, 6LoWPAN. Data protocols - MQTT, CoAP, REST, SOAP. Identification protocols- EPC, uCode, URI. (concept only).

Cloud Computing

Virtualization - advantages, types. Cloud service and deployment models. Cloud implementation - simulators. Features of any commercial cloud service. Sensor clouds - architecture. Fog computing - characteristics and comparison with cloud computing.

MODULE 5 (6 hours)

Applications/Case Studies of IoT Technology

Agricultural IoT - components, advantages, case studies. IoT in healthcare - architecture, components, advantages, risks. Vehicular IoT - components, advantages, applications. IoT in environment monitoring – weather and air pollution monitoring. IoT in energy management, smart metering. Industrial IoT.

Text Books

1. Raj Kamal, *Internet of Things: Architecture and Design Principles*, McGraw-Hill (India) Private Limited, 1st ed., 2017.
2. Sudip Misra, Anandarup Mukherjee, Arijit Roy *Introduction to IoT*, Cambridge University Press, 2nd ed., 2021.
3. Vijay Madisetti and Arshdeep Bahga, *Internet of Things (A Hands on-Approach)*, Orient Blackswan Private Limited -New Delhi, 1sted., 2015.

References

1. Simone Cirani, *Internet of Things: Architecture, Protocols and Standards*, Wiley, 2019.
2. Qusay F. Hassan, *Internet of Things A to Z: Technologies and Applications*, IEEE Press, 2018.
3. Al-Fuqaha et al., *Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications*, IEEE Communications Surveys & Tutorials, 2015.
4. Alasdair Gilchrist, *Industry 4.0: The Industrial Internet of Things*, Apress, 2016.
5. O. Munoz et al., *Development of an IoT Smart Energy Meter with Power Quality Features for a Smart Grid Architecture*, Sustain. Comput. Informatics Syst., vol. 43, p. 100990, 2024, doi: 10.1016/j.suscom.2024.100990.
6. P. Pandiyan et al., *A Comprehensive Review of Advancements in Green IoT for Smart Grids: Paving the Path to Sustainability*, Energy Reports, vol. 11, pp. 5504–5531, 2024, doi: 10.1016/j.egyr.2024.05.021.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Introduction to IoT	6
1.1	Definition and characteristics of IoT	1
1.2	IoT architectural view	1
1.3	Major components: hardware, software and middleware	1
1.4	Communication modules and APIs	1

1.5	Embedded computing: software types, microcontroller platforms and IDEs	1
1.6	Platform selection factors, IoT vs M2M, success factors of IoT	1
	Module 2: Sensors, Actuators and Prototyping Basics	7
2.1	Introduction to sensors and sensing; sensor characteristics (accuracy, sensitivity, resolution, range)	1
2.2	Types of sensors (temperature, pressure, light, motion, humidity) and selection considerations	1
2.3	Interfacing circuits, introduction to actuators; types and characteristics.	1
2.4	Embedded computing basics: software types; hardware units (CPU, memory, I/O)	1
2.5	Integrated Development Environment (IDE): features; introduction to microcontroller platforms	1
2.6	Prototyping platforms ; features, comparison and selection criteria	2
	Module 3: Connectivity Technologies for IoT	8
3.1	Introduction to IoT connectivity and classification	1
3.2	RFID and NFC: features, applications and limitations	1
3.3	Zigbee and Bluetooth/BLE	1
3.4	Wi-Fi (IEEE 802.11)	1
3.5	Cellular technologies: GSM, 3G, 4G LTE	1
3.6	LoRa and LoRaWAN, NB-IoT and Sigfox	1
3.7	Wired communication: UART, SPI, I2C, USB, Ethernet	2
	Module 4: IoT Communication and Cloud Computing	9
4.1	Constrained networks and low power and lossy networks (LLNs)	1
4.2	Infrastructure protocols: IPv4 and IPv6	1
4.3	RPL and 6LoWPAN (concepts)	1
4.4	Data protocols: MQTT, CoAP, REST and SOAP (comparison and use cases)	2
4.5	Identification protocols: EPC, uCode, URI	1
4.6	Virtualization: concepts, advantages and types	1
4.7	Cloud service models and deployment models	1
4.8	Cloud implementation, sensor cloud architecture, fog vs cloud computing	1
	Module 5: Application of IoT Technology	6
5.1	Agricultural IoT: components and advantages	1
5.2	Agricultural IoT case studies	1
5.3	IoT in healthcare: architecture, components, risks	1
5.4	Vehicular IoT: components and applications, Environmental monitoring	2
5.5	IoT in energy management, smart metering and industrial IoT	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Define Internet of Things (IoT).
2. What are the main layers of IoT architecture?
3. Differentiate IoT from M2M and cyber physical systems.

Course Outcome 2 (CO 2)

1. What are some of the common sensing techniques used in IoT ?
2. What are some of the common actuators used with IoT ? Give application examples.
3. Discuss the classification of embedded software.

Course Outcome 3 (CO 3)

1. Classify IoT communication technologies into short-range and long-range with examples.
2. Describe any two wired communication technologies used in IoT.
3. What is the significance of I2C communication?

Course Outcome 4 (CO 4)

1. Which protocol is used for publish-subscribe communication in IoT?
2. When would you use fog computing instead of cloud computing?
3. State the importance of URI.

Course Outcome 5 (CO 5)

1. Describe an example of IoT in agriculture.
2. How is IoT used in healthcare?
3. What is smart metering?

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2028

Course Code: : B24EE4G35

Course Name: : INTERNET OF THINGS

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Compare M2M with IoT.
2. Discuss the success factors of IoT.
3. Explain the operating principle of a resistance temperature sensor.
4. What are the types of embedded software? Mention their significance.
5. Draw the various topologies in Zigbee communication.
6. What are the components required in an RFID system, and the role of each.
7. Mention at least six types of messages in MQTT and its purpose.
8. Give example of any commercial cloud and mention at least six of its features.
9. Mention the tasks of an air pollution monitoring system.
10. Mention at least three features of energy management system in smart grids.

PART B

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

11. Draw and explain the architectural view of an IoT system as suggested by Oracle.

OR

12. Discuss the evolution of IoT from M2M and cyber-physical systems.
13. (a) How can an analog sensor be interfaced with a microcontroller. Draw a schematic diagram showing the various stages in interfacing. (7 Marks)
- (b) Discuss the types of actuators along with their operating principles. (7 Marks)

OR

14. (a) Discuss the factors used for selection of an embedded platform. (4 Marks)
- (b) What are the common features of Arduino prototyping platforms? Draw the layout of any common Arduino board. (10 Marks)
15. Explain the architecture and implementation of LoRa wireless communication technology. (14 Marks)

OR

16. Discuss the features of the following wired connectivity protocols: UART, I2C, Wired USB. (14 Marks)
17. Give the architectural diagrams of a WSN implemented in the traditional way as well as using a sensor cloud platform. Explain how the sensor cloud based approach is advantageous. (14 Marks)

OR

18. Discuss the features and addressing in IPv6. How is it different from IPv4? (14 Marks)
19. Give the components needed in a farm based agricultural IoT system and explain the role of each. (14 Marks)

OR

20. Draw and describe the architecture of a healthcare IoT system and briefly explain the components required for its implementation. (14 Marks)

B24EE4G36	SMART GRID ENGINEERING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The aim of the course is to provide fundamental and applied knowledge of distributed energy resources, microgrids, smart grids and energy management systems for modern power networks. The course covers DER technologies, microgrid concepts and control, smart grid architecture, smart meters, tariffs, and communication networks used in smart grid applications. Students will be able to analyse, design and manage decentralised power systems with effective control, communication and energy management strategies.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the types of distributed energy resources for efficient and sustainable power generation in smart grids. (Cognitive Knowledge Level: Understand)
CO 2	Understand the concepts and operational management of AC, DC, and hybrid microgrids for implementing efficient control strategies. (Cognitive Knowledge Level: Understand)
CO 3	Explain the evolution, global policies of smart grid and analyze performance compared to conventional power grids.(Cognitive Knowledge Level: Understand)
CO 4	Explain advanced metering, pricing schemes, communication networks, and vehicle-to-grid technologies, and apply this knowledge to smart grid infrastructure development and energy management. (Cognitive Knowledge Level: Apply)
CO 5	Explain smart substation and home/building automation components, their functions, interoperability standards and examine their roles and benefits within the smart grid. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	40	20	20
Understand	60	40	40
Apply		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 (8 hours)

Distributed Energy Resources

Combined heat and power systems - micro CHP systems. Wind energy conversion systems - wind turbine operating systems. Solar photovoltaic systems - solar cells, types, modelling of PV modules and arrays. Small-scale hydroelectric power generation. Storage devices - storage batteries, ultracapacitor, flywheel.

MODULE 2 (7 hours)

Concept and Control of Microgrid

Integration of distributed generation to the grid, active distribution network, concept of microgrid, AC microgrids, DC microgrids - monopolar DC link, bipolar DC link, homopolar DC link, hybrid microgrids, comparison, interconnection of microgrids, technical and economical advantages, challenges, operational and management issues.

Control of microgrid, network management requirements - microsource generation control, domestic process control, energy storage, regulation and load shifting, auxiliary services, microgrid controllers - central controller, microsource controller.

MODULE 3 (7 hours)

Introduction to Smart Grid

Smart grid - definitions, characteristics, functions, benefits, opportunities, components, concept of resilient and self-healing, comparison of conventional grid and smart grid, smart grid reference architecture, recent smart grid developments and policies in India, early smart grid initiatives - active distribution networks, virtual power plant.

MODULE 4 (8 hours)

Advanced Metering and Communication Networks

Smart meters, smart sensors, electric tariff - one part tariff, two part tariff and maximum demand tariff, dynamic pricing - critical peak pricing, time of use pricing, real-time pricing. Advanced metering infrastructure (AMI), automated meter reading (AMR), vehicle-to-grid (V2G), plug-in hybrid electric vehicle technology. Introduction to local area network, home area network, neighbourhood area network, wide area network. Bluetooth - topology, architecture.

MODULE 5 (7 hours)

Smart Substation and Automation

Smart substations - protection, monitoring, control devices, sensors, SCADA, substation technology advances, platform for smart feeder applications, interoperability and IEC 61850 - process level, bay level, station level, benefits, role of substation in smart grid. Home and building automation - main controller, control centre, sources of energy, controlled appliances, network interface, NMI console, controller to appliances interface, main controller, automated processes.

Text Books

1. Stuart Borlase, *Smart Grids Infrastructure, Technology and Solutions*, CRC Press Taylor & Francis Group, Pearson Education, 1st ed., 2013.
2. Janaka B. Ekanayake, Nick Jenkins, Kithsiri M. Liyanage, Jianzhong Wu, and Akihiko Yokoyama, *Smart Grid: Technology and Applications*, John Wiley & Sons, 1st ed., 2012
3. Radian Belu, *Smart Grid Fundamentals: Energy Generation, Transmission and Distribution*, CRC Press, Taylor & Francis Group, 1st ed., 2022.
4. S. Chowdhury, S. P. Chowdhury, and P. Crossley, *Microgrids and Active Distribution Networks*, The Institution of Engineering and Technology (IET), 1st ed., 2009.
5. James A. Momoh, *Smart Grid: Fundamentals of Design and Analysis*, Wiley-IEEE Press, John Wiley & Sons , 2nd ed., 2012.

Reference Books

1. Haris M. Khalid and Abdalla Ismail Alzarooni, *Advanced Grid Technologies, Volume 1: Grid Evolution, Smart Grid Fundamentals, and Renewable Energy Integration*, Elsevier, 1st ed., 2025.
2. Krishan Arora, Suman Lata Tripathi, Sanjeevikumar Padmanaban, , *Smart Electrical Grid System: Design Principle, Modernization, and Techniques*, CRC Press, 1st ed., 2022.
3. Dileep G, *Smart Grid Components and Application*, Edberry's publications, 1st ed., 2019.
4. G. Jegadeeswari, R. Elavarasi, S. Angaleswari, and B. Kirubadurai, *Distributed Energy and Smart Grids: Sustainable Energy for the Future*, Bentham Science Publishers, 1st ed., 2026.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No of Lecture/Tutorial Hours
	Total Hours	37 Hours
	Module 1: Distributed Energy Resources	8
1.1	Combined heat and power systems - micro CHP systems	1
1.2	Wind energy conversion systems introduction	1
1.3	Wind energy conversion systems - wind turbine operating systems	1
1.4	Solar photovoltaic systems - solar cells	1
1.5	Solar photovoltaic systems - types, modelling of PV modules and arrays	1
1.6	Small-scale hydroelectric power generation	1
1.7	Storage devices introduction	1
1.8	Storage batteries, ultracapacitor, flywheel	1
	Module 2: Concept and Control of Microgrid	7
2.1	Integration of distributed generation to the grid, active distribution network	1
2.2	Concept of microgrid, AC microgrids	1
2.3	DC microgrids - monopolar DC link, bipolar DC link, homopolar DC link	1
2.4	Hybrid microgrids, comparison	1
2.5	Interconnection of microgrids, technical and economical advantages, challenges, operational and management issues	1
2.6	Control of microgrid, network management requirements - microsource generation control, domestic process control, energy storage, regulation and load shifting, auxiliary services	1
2.7	Microgrid controllers - central controller, microsource controller	1
	Module 3: Introduction to Smart Grid	7
3.1	Definitions need for smart grid, functions of smart grid, opportunities and benefits of smart grid	1
3.2	Concept of resilient and self- healing grid	1
3.3	Components and architecture	1
3.4	Difference between conventional grid and smart grid	1
3.5	Smart grid reference architecture	1
3.6	Present development and international policies of smart grid in India	1
3.7	Early smart grid initiatives - active distribution networks, virtual power plant	1
	Module 4: Advanced Metering and Communication Networks	8
4.1	Introduction to smart meters, smart sensors	1

4.2	Electric tariff - one part tariff, two part tariff and maximum demand tariff, dynamic pricing - critical peak pricing, time of use pricing, real-time pricing	1
4.3	Automatic Meter Reading (AMR) System, services and functions, components of AMR systems	1
4.4	Advanced Metering Infrastructure (AMI)	1
4.5	Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid, Grid to Vehicle.	1
4.6	Introduction to communication networks, local area network	1
4.7	Home area network, Neighbourhood area network	1
4.8	Wide area network, bluetooth - topology, architecture.	1
	Module 5: Smart Substation and Automation	7
5.1	Smart substations - protection, monitoring, control devices	1
5.2	Sensors, SCADA, substation technology advances	1
5.3	EC 61850 substation architecture and substation automation system, role of substation in smart grid	1
5.4	Feeder automation field devices	1
5.5	Feeder automation - communication networks, information management, control systems, applications	
5.6	Home and building automation - main controller, control centre, sources of energy, controlled appliances	1
5.7	Home and building automation network - interface, NMI console, controller to appliances interface, main controller, automated processes	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1)

1. Define Combined Heat and Power (CHP) system. What is a micro-CHP system?
2. State the advantages of small-scale hydroelectric systems.
3. Explain the working and features of ultracapacitors.

Course Outcome 2 (CO 2)

1. Define a microgrid. Mention its main components.
2. List the main objectives of microgrid control systems.
3. What is load shifting in microgrids?

Course Outcome 3 (CO 3)

1. Explain the smart grid reference architecture.
2. Differentiate between conventional grid and smart grid.
3. What are the functions and opportunities of smart grid .

Course Outcome 4 (CO 4)

1. Define a smart meter. State any two advantages.
2. What is meant by electric tariff?
3. Explain the role of EVs in smart grid systems.

Course Outcome 5 (CO 5)

1. What is the role of the main controller in home automation?
2. What is SCADA? State its function in substations.
3. What are protection devices used in smart substations?

MODEL QUESTION PAPER

QP CODE:

Pages: 2

Reg.No.:

Name:

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

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2028

Course Code: : B24EE4G36

Course Name: : SMART GRID ENGINEERING

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Describe the principle of flywheel energy storage system.
2. Explain the operating principle of a wind turbine.
3. Compare AC, DC, and hybrid microgrids.
4. Mention the economic challenges of microgrids.
5. Explain the concept of resilient and self-healing grid.
6. Define smart grid concept and explain its necessity.
7. Define Local Area Network (LAN).
8. Explain critical peak pricing.
9. What is a smart substation?
10. List the main components of a home automation system.

PART B

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

11. Explain the construction and working of a solar cell. Discuss different types of solar cells with advantages and disadvantages. (14 marks)

OR

12. Explain the working principle of a Combined Heat and Power (CHP) system. Describe micro-CHP systems with advantages and applications. (14 marks)
13. (a) Discuss the challenges in integration, operation, and management of microgrids in power systems. (7 marks)
(b) Discuss the technical and economic advantages of integrating distributed generation into modern power systems. (7 marks)

OR

14. Discuss the role of energy storage systems in microgrids. Explain regulation, load shifting, and auxiliary services. (14 marks)
15. With the help of block diagram explain the architecture of smart grid. What are the challenges of smart grid technology? (14 marks)

OR

16. Explain the recent smart grid developments and policies in India. (14 marks)
17. Explain Advanced Metering Infrastructure (AMI) with a neat block diagram. Discuss its components, working, and advantages. (14 marks)

OR

18. Describe plug-in hybrid electric vehicle (PHEV) technology. Explain its components, working principle, and advantages over conventional vehicles. (14 marks)
19. Discuss the features and benefits of IEC 61850 in substation automation systems. (14 marks)

OR

20. Explain the architecture of a home and building automation system. Describe main controller, control centre, and network interface. (14 marks)

B24EE4L14	PROJECT PHASE II	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	12	3	6	2024

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:

CO 1	Model, analyze, and solve real-world engineering problems by applying cross-domain knowledge (Cognitive Knowledge Level: Apply)
CO 2	Develop, test, and validate sustainable products/processes/technologies aligned with relevant UN SDGs. (Cognitive Knowledge Level: Apply)
CO 3	Function effectively in teams, manage tasks/resources, and adhere to ethical/professional norms. (Cognitive Knowledge Level: Apply)
CO 4	Identify research/technology gaps and propose innovative solutions with implementation evidence. (Cognitive Knowledge Level: Analyse)
CO 5	Organize and communicate technical findings effectively through reports, presentations, and publications. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes (POs)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	2	2	2	1	1	1	1	2
CO2	2	2	3	1	1	3	2	1	1	1	2
CO3	-	-	-	-	2	1	2	3	2	3	2
CO4	2	3	3	2	2	2	1	1	-	2	2
CO5	-	-	-	-	2	1	1	1	3	2	2

Abstract Program Outcomes (POs) defined by National Board of Accreditation
(New Tier-1, GAPC v4.0 aligned with Washington Accord)

Program Outcomes (POs)

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, and 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 Marks**

Component	Marks
Project progress evaluation by guide	30
Two interim evaluations by Evaluation Committee	50
Final evaluation by Final Evaluation Committee	40
Quality of the report evaluated by committee	25
Paper publication / acceptance in conference or indexed journal	5
Total	150

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, Work Breakdown Structure (WBS), and balanced task allocation.

- **Literature Survey (4):** Demonstrates outstanding depth and breadth, updated from Phase-I.
- **Student's Diary / Daily Log (7):** Regular signed records of progress, observations, sketches, and reflections; promotes proper documentation and reasoning.
- **Individual Contribution (9):** Clear evidence of meaningful and equitable contribution from each student.
- **Project Completion / Demonstration (5):** Functional prototype or demonstration presented to the guide; objectives achieved and 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/ ineffective; 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.

Continued on next page

Aspect / Parameter	Marks	Poor	Fair	Very Good	Outstanding
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; some gap analysis evident.	Outstanding in-depth, critical survey; broad/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.

Continued on next page

Aspect / Parameter	Marks	Poor	Fair	Very Good	Outstanding
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)

No.	Parameter	Marks	Poor (0–1)	Fair (2–3)	Very Good (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	Effectiveness of task distribution [CO3/PO8] (Group)	5	No distribution; members unclear on roles.	Allocated but ineffective/skewed; some members underutilized.	Good allocation via discussions/journal; mostly equitable/followed.	Excellent equitable distribution per capabilities; well documented (journal/brainstorming); all actively contribute.

2-c	Adherence to project schedule [CO4/PO10] (Group)	5	Minimal planning; no adherence to Phase-I plan; unclear resources/budget; no journal.	Some progress over Phase-I; vague resources/budget; partial schedules.	Good planning/follow-up; resources listed; plan mostly followed; journal updated somewhat.	Detailed planning/tools (e.g., revision control); resource procurement on track; journal comprehensive; strong team interaction.
2-d	Interim Results & Progress [CO1/CO5] (Group)	5	No meaningful progress/results from Phase-I continuation.	Few results; limited analysis/inferences.	Several results achieved; issues identified with partial solutions.	Significant progress; clear inferences; SDG/societal impact evident.
2-e	Presentation & Documentation [CO5/PO9] (Group/Individual)	5	Poor clarity/organization; no understanding shown.	Needs major improvement in structure/delivery.	Adequate content/delivery.	Professional, confident, well-structured presentation.

Rubrics for Interim Evaluation – 2 (25 Marks)

No.	Parameter	Marks	Poor (0-3)	Fair (4-6)	Very Good (7-9)	Outstanding (10)
2-f	Application of Engineering knowledge [CO1/PO1-PO5] (Individual)	10	No evidence of knowledge application in implementation.	Basic application; inadequate for methodology.	Reasonable application in design/testing.	Excellent, adaptive use of knowledge for robust solutions.
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.

No.	Parameter	Marks	Poor (0-3)	Fair (4-6)	Very Good (7-9)	Outstanding (10)
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)

No.	Parameter	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.

No.	Parameter	Marks	Poor (0-3)	Fair (4-6)	Very Good (7-9)	Outstanding (10)
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)

No.	Parameter	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.



MINOR

B24EEML1	MINOR PROJECT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	12	6	2024

Preamble

The course aims to assess students' ability to transform theoretical knowledge into a functional working model. It enables experience in organizing and implementing small-scale projects and facilitates the design and development of moderately complex systems (hardware or hardware-software combinations) with practical and sustainable applications.

Course Plan

In groups of up to 4 students, design and develop a moderately complex system addressing a real-world need. A functional working prototype/model is required, incorporating product design principles such as 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 is evaluated through a minimum of two reviews by a committee. Students submit a project report and demonstrate the product against specifications. Emphasis is given to innovation, reliability, aesthetics/ergonomics, and societal/SDG relevance.

Course Outcomes

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

CO1	Apply acquired knowledge in the selected technology area for project development and implementation. (Cognitive Knowledge Level: Apply)
CO2	Identify, discuss, and justify technical/design aspects of the project systematically. (Cognitive Knowledge Level: Analyze)
CO3	Reproduce, improve, and refine technical aspects for engineering projects. (Cognitive Knowledge Level: Apply)
CO4	Collaborate effectively as a team in technical project development. (Cognitive Knowledge Level: Apply)
CO5	Communicate and report project activities and findings effectively (written/oral). (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	2	2	3	1	1	1	1	2
CO2	3	3	3	2	1	3	1	1	1	2	2
CO3	3	3	3	2	2	3	1	1	1	1	2
CO4					1	2	3	2	3	2	
CO5				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-voce : 20 Marks
- Presentation : 10 Marks

Enhanced rubrics for all evaluation components.

1. Guide's Evaluation (CIE – 15 Marks)

Holistic assessment by the guide based on regular monitoring, involvement, and progress.

Aspect	Marks Allocation	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/unclear 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) Panel assessment (reviews, interim progress, knowledge, involvement).

Aspect	Marks Allocation	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; excellent structure and readability; proper citations with SDG discussion.
- **Viva-voce (20 Marks) [CO2, CO5 / PO2, PO9]**
 - Poor (0–5): Unable to explain basics; no understanding.
 - Fair (6–10): Limited answers; frequent prompting required.
 - 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.

The logo of Mar Athanasius College of Engineering is a large, faint watermark in the background. It features a circular gear-like border. Inside the circle is a light blue field containing a large orange cross with eight rays emanating from its center. Below the cross is a green mountain range. At the base of the mountains is an open book with orange pages. A yellow banner curves across the bottom of the logo, containing the text 'KNOWLEDGE IS POWER' in purple capital letters.

HONOURS

B24EEHL1	HONOURS PROJECT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	6	9	6	2024

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.

Prerequisites

Course Plan

- Identify an advanced core engineering topic in consultation with the faculty/advisor.
- Conduct an in-depth literature review and perform gap analysis.
- Define objectives and develop a systematic methodology (with SDG alignment where relevant).
- Design, fabricate, or develop hardware/software/code; implement, test, and refine the system.
- Demonstrate novelty, functionality, reliability, and aesthetics/ergonomics through results and outputs.
- Evaluate progress through a minimum of two reviews by the committee.
- Submit a comprehensive project report including full design specifications.

- Explore opportunities for conference/journal publication or IPR filing.

Course Outcomes

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

CO 1	Apply and extend acquired knowledge in a selected core engineering branch/technology area for advanced Honours project development. (Cognitive Knowledge Level: Apply)
CO 2	Identify, discuss, justify, and systematically approach technical/design aspects of innovative projects with SDG/societal relevance. (Cognitive Knowledge Level: Analyze)
CO 3	Reproduce, improve, refine, and validate technical solutions for complex engineering projects. (Cognitive Knowledge Level: Apply/Analyze)
CO 4	Collaborate effectively as a team in the development and management of advanced technical projects. (Cognitive Knowledge Level: Apply)
CO 5	Communicate and report project activities, findings, and innovations effectively in both written and oral forms. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	2	2	3	1	1	1	1	2
CO2	3	3	3	3	2	3	2	1	1	2	2
CO3	3	3	3	2	2	3	1		1	1	2
CO4					1	1	2	3	2	3	2
CO5					1		1	1	3	2	2

Evaluation Scheme

Total: 150 marks (CIE 75 + ESE 75; ESE duration 1 hour).

Evaluation by a 3-member committee (HoD/senior faculty, academic/program coordinator, project guide/coordinator). The committee assesses completion, functionality/specification demonstration, presentation, viva voce, knowledge, and level of involvement.

Split-up of CIE (75 Marks)

- Attendance : 10
- Marks awarded based on guide's evaluation : 15

- Project Report : 10
- Evaluation by Committee : 40

Split-up of ESE (75 Marks)

- Level of completion : 10
- Demonstration of functionality : 25
- Project Report : 10
- Viva-voce : 20
- Presentation : 10

Enhanced rubrics with progressive levels tied to COs/POs/SDGs are used, ensuring evidence-based and fair evaluation.

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/ineffective	Reasonable scheduling; mostly balanced	Detailed WBS/timelines; 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)	Very Good (25–32)	Outstanding (33–40)
Technical Depth/Justification/ SDG Alignment [CO1–CO3 / PO1–PO6]	15	No justification	Basic analysis	Reasonable approach	Strong SDG link	Exceptional innovation
Teamwork/Involvement [CO4 / PO8]	10	No collaboration	Limited teamwork	Good teamwork	Effective collaboration	Leadership
Interim Progress/Functionality [CO3 / PO3, PO5]	15	No progress	Partial results	Good progress	Reliable system	Highly innovative/validated

3. ESE – Level of Completion (10 Marks)

- Poor (0–2): Incomplete/no model
- Fair (3–4): Basic with major gaps
- Good (5–6): Most features completed
- Very Good (7–8): Near complete
- Outstanding (9–10): Fully advanced; exceeds specifications/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 system
- Outstanding (21–25): Fully functional; innovative and SDG-aligned

5. ESE – Project Report (10 Marks)

- Poor (0–2): Poor/no references
- Fair (3–4): Basic/inconsistent
- Good (5–6): Systematic with references
- Very Good (7–8): Professional with SDG discussion
- Outstanding (9–10): Exemplary/publishable quality

6. ESE – Viva-voce (20 Marks)

- Poor (0–4): No understanding
- Fair (5–8): Basic knowledge
- Good (9–12): Good grasp
- Very Good (13–16): Strong understanding
- Outstanding (17–20): Deep insight with SDG integration

7. ESE – Presentation (10 Marks)

- Poor (0–2): Unclear delivery
- Fair (3–4): Needs improvement
- Good (5–6): Clear and structured
- Very Good (7–8): Professional delivery
- Outstanding (9–10): Engaging with excellent communication