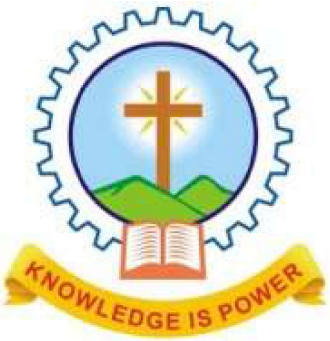
MAR ATHANASIUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution
Kothamangalam, Kerala, India



B. TECH MECHANICAL ENGINEERING

SCHEME AND SYLLABUS

MAR ATHANASIUS COLLEGE OF ENGINEERING

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B. TECH MECHANICAL 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	B24ES1T01B	PROBLEM SOLVING AND PROGRAMMING TECHNIQUES (B)	2-1-0-4	3	3
C	B24ES1T07	FUNDAMENTALS OF ELECTRICAL ENGINEERING	2-1-0-4	3	3
D	B24ES1T05B	BASIC CIVIL AND MECHANICAL ENGINEERING (B)	2-2-0-5	4	4
E	B24ME1T01	ENGINEERING GRAPHICS	2-1-2-4	5	4
F	B24ES1L04B	BASIC CIVIL AND MECHANICAL WORKSHOP (B)	0-0-2-1	2	1
G	B24ES1L01B	PROGRAMMING LABORATORY (B)	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**	**21**

SEMESTER 2

SLOT	COURSE NO.	COURSES	L-T-P-S	HOURS	CREDIT
A	B24MA1T02	ORDINARY DIFFERENTIAL EQUATIONS AND TRANSFORMS	3-1-0-5	4	4
B	B24PH1T01B	ENGINEERING PHYSICS (B)	2-1-0-4	3	3
C.	B24CY1T01A	ENGINEERING CHEMISTRY (A)	2-1-0-4	3	3
D	B24ES1T08	FUNDAMENTALS OF ELECTRONICS ENGINEERING	2-1-0-4	3	3
E	B24ME1T02	STATICS AND DYNAMICS FOR ENGINEERS	3-1-0-5	4	4
F	B24ES1L05	ELECTRICAL AND ELECTRONICS WORKSHOP	0-0-2-1	2	1
G	B24ME1L01	COMPUTER AIDED MACHINE DRAWING	0-0-3-3	3	3
H	B24PC1L01C	PHYSICS(B) AND CHEMISTRY(A) LAB	0-0-1-1	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**	**22**

SEMESTER 3

SLOT	COURSE NO.	COURSES	L-T-P-S	HOURS	CREDIT
A	B24MA2T03A	COMPLEX VARIABLES AND APPLICATIONS OF PDE	3-1-0-5	4	4
B	B24ME2T01	MECHANICS OF SOLIDS	3-1-0-5	4	4
C	B24ME2T02	MECHANICS OF FLUIDS	3-1-0-5	4	4
D	B24ME2T03	METALLURGY AND MATERIALS SCIENCE	2-1-0-4	3	3
E	B24HU2T02	ENTREPRENEURSHIP AND MANAGEMENT SKILLS FOR ENGINEERS	2-1-0-4	3	3
G	B24ME2L02	MATERIAL TESTING LAB	0-0-3-2	3	2
H	B24ME2L03	MACHINE TOOLS LAB	0-0-3-2	3	2
I	B24MC2T04	UNIVERSAL HUMAN VALUE AND CONSTITUTIONAL RIGHTS	2-0-0-2	2	P/F
J	B24MC2T05	ENERGY CONSERVATION AND ENVIRONMENTAL SUSTAINABILITY	2-0-0-2	2	P/F
M	B24MEM3x	MINOR	3-1-0-5	4	4
			TOTAL	**32**	**22**

SEMESTER 4

SLOT	COURSE NO.	COURSES	L-T-P-S	HOURS	CREDIT
A	B24MA2T04B	STATISTICAL ANALYSIS AND NUMERICAL METHODS	3-1-0-5	4	4
B	B24ME2T04	THEORY OF MACHINES	3-1-0-5	4	4
C	B24ME2T05	METROLOGY AND MACHINE TOOLS	3-1-0-4	4	3
D	B24ME2T06	ENGINEERING THERMODYNAMICS	3-1-0-5	4	4
E	B24HU2T01	BUSINESS ECONOMICS AND FINANCIAL MANAGEMENT	3-0-0-4	3	3
F	B24ME2T07	FLUID MACHINES	2-1-0-4	3	3
G	B24ME2L04	MECHANICAL MEASUREMENTS LAB	0-0-3-2	3	2
H	B24ME2L05	FLUID MECHANICS AND MACHINES LAB	0-0-3-2	3	2
M	B24MEM4x	MINOR	3-1-0-5	4	4
N	B24MEH4x	HONOURS	3-1-0-5	4	4
			TOTAL*	**36**	**25**

SEMESTER 5

SLOT	COURSE NO.	COURSES	L-T-P-S	HOURS	CREDIT
A	B24ME3T01	DYNAMICS AND DESIGN OF MACHINES	3-1-0-5	4	4
B	B24ME3T02	THERMAL POWER ENGINEERING	3-1-0-5	4	4
C	B24ME3T03	MANUFACTURING TECHNOLOGY	3-1-0-5	4	4
D	B24ME3T04	ROBOTICS AND AUTOMATION	3-1-0-5	4	4
E	B24ME3T05	INDUSTRIAL AND SYSTEMS ENGINEERING	2-1-0-4	3	3
F	B24ME3P1x	PROGRAMME ELECTIVE I	2-1-0-4	3	3
G	B24ME3L06	ROBOTICS AND AUTOMATION LAB	0-0-3-2	3	2
H	B24ME3L07	THERMAL POWER LAB	0-0-3-2	3	2
M	B24MEM5x	MINOR	3-1-0-5	4	4
N	B24MEH5x	HONOURS	3-1-0-5	4	4
			TOTAL*	**36**	**26**

PROGRAMME ELECTIVE I

B24ME3P11	OPERATIONS MANAGEMENT
B24ME3P12	ORGANIZATIONAL BEHAVIOUR & HUMAN RESOURCES MANAGEMENT
B24ME3P13	STRATEGIC MARKETING MANAGEMENT
B24ME3P14	OPERATIONS RESEARCH
B24ME3P15	OBJECT ORIENTED PROGRAMMING
B24ME3P16	DATA ANALYTICS FOR ENGINEERS
B24ME3P17	BASICS OF ARDUINO PROGRAMMING

SEMESTER 6

SLOT	COURSE NO.	COURSES	L-T-P-S	HOURS	CREDIT
A	B24ME3T06	DESIGN OF MACHINE ELEMENTS	3-1-0-5	4	4
B	B24ME3T07	HEAT AND MASS TRANSFER	3-1-0-5	4	4
C	B24ME3T08	FINITE ELEMENT METHODS	3-1-0-5	4	4
D	B24ME3T09	ADVANCED AUTOMOTIVE SYSTEMS	3-1-0-5	4	4
E	B24ME3P2x	PROGRAMME ELECTIVE II	2-1-0-4	3	3
F	B24ME3G1x	OPEN ELECTIVE I	2-1-0-4	3	3
G	B24ME3L08	THERMAL SYSTEMS LAB	0-0-3-2	3	2
H	B24ME3L09	COMPUTER AIDED DESIGN AND ANALYSIS LAB	0-0-3-2	3	2
M	B24MEM6x	MINOR	3-1-0-5	4	4
N	B24MEH6x	HONOURS	3-1-0-5	4	4
			TOTAL*	**36**	**26**

PROGRAMME ELECTIVE II

B24ME3P21	MAINTENANCE MANAGEMENT AND RELIABILITY ENGINEERING
B24ME3P22	FINANCIAL ENGINEERING
B24ME3P23	TECHNOLOGY MANAGEMENT
B24ME3P24	INDUSTRY 4.0 AND INTERNET OF THINGS
B24ME3P25	DATA STRUCTURES AND ALGORITHMS
B24ME3P26	SYSTEM MODELING AND SIMULATION
B24ME3P27	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING
B24ME3P28	ALGORITHMS FOR NON TRADITIONAL OPTIMIZATION

OPEN ELECTIVE I

B24ME3G11	QUANTITATIVE TECHNIQUES FOR ENGINEERS
B24ME3G12	INTRODUCTION TO PRODUCT DEVELOPMENT
B24ME3G13	OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT
B24ME3G14	AUTOMOTIVE TECHNOLOGY
B24ME3G15	NON DESTRUCTIVE TESTING
B24ME3G16	MATERIAL HANDLING SYSTEMS
B24ME3G17	FUNDAMENTALS OF DATA ANALYSIS

SEMESTER 7

SLOT	COURSE NO.	COURSES	L-T-P-S	HOURS	CREDIT
A	B24ME4T01	PROJECT MANAGEMENT	2-1-0-4	3	3
B	B24ME4P3x	PROGRAMME ELECTIVE III	2-1-0-4	3	3
C	B24ME4P4x	PROGRAMME ELECTIVE IV	2-1-0-4	3	3
D	B24ME4G2x	OPEN ELECTIVE II	2-1-0-4	3	3
E	B24HU4T04	DISASTER MANAGEMENT AND INDUSTRIAL SAFETY	2-1-0-4	3	3
G	B24ME4L10	ADVANCED MECHANICAL ENGINEERING LAB	0-0-3-2	3	2
H	B24ME4L11	PROJECT PHASE 1	0-0-6-2	6	3
J	B24ME4L12	SEMINAR	0-0-4-1	4	2
K	B24ME4T02	VIVA VOCE	0-0-0-0	-	1
M	B24MEM7x	MINOR	3-1-0-5	4	4
N	B24MEH7x	HONOURS	3-1-0-5	4	4
			TOTAL*	**36**	**23**

PROGRAMME ELECTIVE III

B24ME4P31	PRODUCT DESIGN AND DEVELOPMENT
B24ME4P32	ADVANCED DESIGN SYNTHESIS
B24ME4P33	INDUSTRIAL TRIBOLOGY
B24ME4P34	RENEWABLE ENERGY
B24ME4P35	COMPUTATIONAL FLUID DYNAMICS
B24ME4P36	INDUSTRIAL HYDRAULICS
B24ME4P37	ADVANCED METAL JOINING TECHNIQUES
B24ME4P38	ADVANCED MANUFACTURING TECHNIQUES
B24ME4P39	SURFACE ENGINEERING AND COATING TECHNOLOGY

PROGRAMME ELECTIVE IV

B24ME4P41	OPTIMIZATION TECHNIQUES AND APPLICATIONS
B24ME4P42	FRACTURE MECHANICS
B24ME4P43	PRESSURE VESSEL AND PIPING DESIGN
B24ME4P44	FUNDAMENTALS OF UNMANNED AERIAL VEHICLES (UAV)
B24ME4P45	REFRIGERATION AND CRYOGENICS
B24ME4P46	HEAT TRANSFER EQUIPMENT DESIGN
B24ME4P47	ADVANCED NON DESTRUCTIVE TESTING
B24ME4P48	MEMS AND NANOTECHNOLOGY
B24ME4P49	ADVANCED NUMERICALLY CONTROLLED MACHINING

OPEN ELECTIVE II

B24ME4G21	INTRODUCTION TO BUSINESS ANALYTICS
B24ME4G22	PATENTS AND INTELLECTUAL PROPERTY RIGHTS
B24ME4G23	FUNDAMENTALS OF LOGISTICS AND SUPPLY CHAIN MANAGEMENT
B24ME4G24	RENEWABLE ENERGY ENGINEERING
B24ME4G25	INTRODUCTION TO 3D PRINTING
B24ME4G26	FUNDAMENTALS OF COMPOSITE MATERIALS
B24ME4G27	INTRODUCTION TO ACOUSTICS AND NOISE CONTROL

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	B24ME4P5x	PROGRAMME ELECTIVE V	2-1-0-4	3	3
B	B24ME4P6x	PROGRAMME ELECTIVE VI	2-1-0-4	3	3
C	B24ME4G3x	OPEN ELECTIVE III	2-1-0-4	3	3
		AND			
H	B24ME4L13	PROJECT PHASE 2	0-0-12-3	12	6
M	B24MEML1	MINOR PROJECT#	0-0-3-12	3	6
N	B24MEHL1	HONOURS PROJECT	0-0-6-9	6	6
			TOTAL*	30	15

#Can be done in S7 as well

* Semester total does not include the credits of honors and minor courses

** Students can take up the MOOC courses from semester 5 onwards. The courses should be from the list approved by the Board of Studies.

PROGRAMME ELECTIVE V

B24ME4P51	ADVANCED THEORY OF VIBRATION
B24ME4P52	ACOUSTICS AND NOISE CONTROL
B24ME4P53	COMPOSITE MATERIALS
B24ME4P54	GAS DYNAMICS AND JET PROPULSION
B24ME4P55	IC ENGINE COMBUSTION AND POLLUTION
B24ME4P56	HEATING VENTILATION AND AIR CONDITIONING
B24ME4P57	ADDITIVE MANUFACTURING
B24ME4P58	POWDER METALLURGY
B24ME4P59	METAL FORMING AND INJECTION MOULDING

PROGRAMME ELECTIVE VI

B24ME4P61	SIX SIGMA AND QUALITY MANAGEMENT
B24ME4P62	OCCUPATIONAL HEALTH AND SAFETY
B24ME4P63	MEP SYSTEMS AND MANAGEMENT
B24ME4P64	PIPING DESIGN AND MANUFACTURING
B24ME4P65	LOGISTICS AND SUPPLY CHAIN MANAGEMENT
B24ME4P66	BASICS OF PLC PROGRAMMING

OPEN ELECTIVE III

B24ME4G31	FACILITY LOCATION AND PLANNING
B24ME4G32	TOTAL QUALITY MANAGEMENT
B24ME4G33	INTRODUCTION TO INDUSTRY 4.0
B24ME4G34	MAINTENANCE ENGINEERING AND MANAGEMENT
B24ME4G35	NANOTECHNOLOGY AND APPLICATIONS
B24ME4G36	INFORMATION TECHNOLOGY MANAGEMENT

MINOR

Basket I (Design)

SEMESTER	COURSE NO.	COURSE NAME
S3	B24MEM31	MECHANICS OF MATERIALS
S4	B24MEM41	MECHANICS OF MACHINES
S5	B24MEM51	DYNAMICS OF MACHINES
S6	B24MEM61	MACHINE DESIGN
S7	B24MEM71	DESIGN THINKING AND PRODUCT DEVELOPMENT
S8	B24MEML1	MINOR PROJECT

Basket II (Thermal)

SEMESTER	COURSE NO.	COURSE NAME
S3	B24MEM32	FLUID MECHANICS & MACHINERY
S4	B24MEM42	THERMODYNAMICS
S5	B24MEM52	THERMAL SCIENCE AND ENGINEERING
S6	B24MEM62	HEAT TRANSFER
S7	B24MEM72	AUTOMOTIVE SYSTEMS
S8	B24MEML1	MINOR PROJECT

Basket III (Production)

SEMESTER	COURSE NO.	COURSE NAME
S3	B24MEM33	MATERIAL SCIENCE & TECHNOLOGY
S4	B24MEM43	MANUFACTURING PROCESS
S5	B24MEM53	PRECISION MANUFACTURING AND MACHINING TECHNOLOGY
S6	B24MEM63	INTRODUCTION TO OPERATIONS MANAGEMENT
S7	B24MEM73	FUNDAMENTALS OF ROBOTICS AND AUTOMATION
S8	B24MEML1	MINOR PROJECT

HONOURS

Group I (Design)

SEMESTER	COURSE NO.	COURSE NAME
S4	B24MEH41	DESIGN OF HYDRAULIC AND PNEUMATIC EQUIPMENTS
S5	B24MEH51	DESIGN FOR MANUFACTURING AND ASSEMBLY
S6	B24MEH61	ADVANCED THEORY OF MACHINES
S7	B24MEH71	TRIBOLOGY
S8	B24MEHL1	HONOURS PROJECT

Group II (Thermal)

SEMESTER	COURSE NO.	COURSE NAME
S4	B24MEH42	ADVANCED FLUID MECHANICS
S5	B24MEH52	MEASUREMENT METHODS FOR ENGINEERS
S6	B24MEH62	SOLAR THERMAL ENGINEERING
S7	B24MEH72	AEROSPACE ENGINEERING
S8	B24MEHL1	HONOURS PROJECT

Group III (Production)

SEMESTER	COURSE NO.	COURSE NAME
S4	B24MEH43	ADVANCED ENGINEERING MATERIALS
S5	B24MEH53	ADVANCED MATERIAL PROCESSING
S6	B24MEH63	ADVANCED CHARACTERISATION TECHNIQUES
S7	B24MEH73	JIGS AND FIXTURES
S8	B24MEHL1	HONOURS PROJECT

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B.TECH MECHANICAL ENGINEERING

SEMESTER 1

SYLLABUS

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.

Prerequisites: 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 KnowledgeLevel : 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

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	2	1			1						
CO 2	2	1				1					
CO 3	2	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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 5 marks

End Semester Examination Pattern

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

SYLLABUS

MODULE 1 (Linear Algebra)

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

Systems of linear equations, Solution by Gauss elimination, row echelon form and rank of a matrix, fundamental theorem for linear systems (homogeneous and non-homogeneous, without proof), Eigen values and eigenvectors. Diagonalization of matrices, orthogonal transformation, quadratic forms and their canonical forms.

MODULE 2 (Multivariable Calculus-Differentiation)

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

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

MODULE 3 ((Multivariable Calculus-Integration))

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

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

MODULE 4 (Calculus of vector functions)

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

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

MODULE 5 (Vector integral theorems)

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

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

Text Books

1. H. Anton, I. Biven, S. Davis, "Calculus", Wiley, 10^{th} edition, 2015.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 10^{th} edition, John Wiley & Sons, 2015.

Reference Books

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

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No of Lecture/Tutorial Hours
	Total	45 hours
1	**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	Eigen values and eigen vectors	2
1.4	Diagonalization of matrices	2
1.5	Orthogonal transformation, quadratic forms and their canonical forms.	2
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	**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 laminas	2
3.4	Triple integrals, volume calculated as triple integral, triple integral in cylindrical and spherical coordinates.	3
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	**Vector Integral Theorems**	9
5.1	Green's theorem and it's applications	2
5.2	Surface integrals, flux integral and their evaluation	3
5.3	Divergence theorem and applications	2
5.4	Stokes theorem and applications	2

CO ASSESSMENT QUESTIONS

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

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

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

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

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

1. Evaluate $\iint_D (x + 2y)\, dA$ where D is the region bounded by the parabolas

   $y = 2x^2$ and $y = 1 + x^2$.

2. Explain how you would find the volume under the surface $z = f(x, y)$ and over a specific region D in the xy plane using triple integral?

3. Find the mass and centre of gravity of a triangular lamina with vertices (0,0), (2,1), (0,3) if the density function is $f(x, y) = x + y$.

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

1. How would you calculate the speed, velocity and acceleration at any instant of a particle moving in space whose position vector at time t is $\mathbf{r}(t)$?

2. Find the work done by the force field $\mathbf{F} = (e^x - y^3)\ \mathbf{i} + (\cos y + x^3)\ \mathbf{j}$ on a particle that travels once around the unit circle centered at origin having radius 1.

3. When do you say that a vector field is conservative? What are the implications if a vector field is conservative?

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

1. Write any one application each of line integral, double integral and surface integral.

2. Use the divergence theorem to find the outward flux of the vector field $\mathbf{F}(x, y, z) = z\mathbf{k}$ across $x^2 + y^2 + z^2 = a^2$.

3. State Greens theorem. Use Green's theorem to express the area of a plane region bounded by a curve as a line integral.

MODEL QUESTION PAPER

QP CODE: **Pages: 3**

Reg.No.: .....

Name: .....

MAR ATHANASIUS 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 **r** where $\mathbf{r} = x\mathbf{i} + y\mathbf{j} + z\mathbf{k}$ conservative. Justify your answer.
8. Find a unit vector normal to the surface $x^3 + y^3 + 3xyz = 3$ at the point (1,2,-1).
9. What is the outward flux of $\mathbf{F}(x, y, z) = x\mathbf{i} + y\mathbf{j} + z\mathbf{k}$ across any unit cube.
10. What is the relationship between Green's theorem and Stokes theorem?

PART B

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

11. (a) Solve the following system of equations
y + z - 2w = 0
2x - 3y - 3z + 6w = 2
4x + y + z - 2w = 4 7

(b) Find the eigen values and eigen vectors of the matrix $\begin{bmatrix} 2 & 2 & -3 \\ 2 & 1 & -6 \\ -1 & 2 & 0 \end{bmatrix}$ 7

OR

12. (a) Diagonalize the matrix $\begin{bmatrix} -1 & 2 & -2 \\ 2 & 4 & 1 \\ 2 & 4 & 1 \end{bmatrix}$ 7

(b) What kind of conic section the quadratic form $3x^2 + 22xy + 3y^2 = 0$ represents? Transform it to principal axes. 7

13. (a) Find the local linear approximation to $f(x, y) = \sqrt{x^2 + y^2}$ at the point (3,4). Use it to approximate $f(3.04, 3.98)$. 7

(b) Let $w = \sqrt{x^2 + y^2 + z^2}$, x = cos$\theta$, y = sin$\theta$, z = tan$\theta$. Use chain rule to find $\frac{dw}{d\theta}$ when $\theta = \frac{\pi}{4}$ 7

OR

14. (a) Let $z = f(x, y)$ where $x = rcos\theta$, $y = rsin\theta$, prove that

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

7

(b) Locate all relative maxima, relative minima and saddle points of $f(x, y) = xy + \frac{a^3}{x} + \frac{b^3}{y}$,$(a \neq 0, b \neq 0)$. 7

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

(b) Evaluate $\int_0^4 \int_{\sqrt{y}}^2 e^{x^3}\, dx\, dy$ by changing the order of integration. 7

OR

16. (a) Find the volume of the solid bounded by the cylinder $x^2 + y^2 = 4$ and the planes $y + z = 4$ and $z = 0$. 7

(b) Evaluate $\iiint \sqrt{1 - x^2 - y^2 - z^2}\, dx\, dy\, dz$, taken throughout the volume of the sphere $x^2 + y^2 + z^2 = 1$ 7

17. (a) Prove that the force field $\mathbf{F} = e^y\mathbf{i} + xe^y\mathbf{j}$ is conservative in the entire xy-plane. 7

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

OR

18. (a) Find the divergence of the vector field $\mathbf{F} = x^3y^2z\mathbf{i} + xyz^3\mathbf{j} + xyz^2\mathbf{k}$ at (1,1,1). 7

(b) Find the work done by the force field $\mathbf{F}$(x, y, z) = xy$\mathbf{i}$ + yz$\mathbf{j}$ + xz$\mathbf{k}$ along C where C is the curve $\mathbf{r}(t) = t\mathbf{i} + t^2\mathbf{j} + t^3\mathbf{k}$. 7

19. (a) Use divergence theorem to find the outward flux of the vector field $\mathbf{F} = 2x\mathbf{i} + 3y\mathbf{j} + z^3\mathbf{k}$ across the unit cube bounded by x = 0, y = 0, z = 0, x =1, y = 1, z = 1. 7

(b) Find the circulation of $\mathbf{F}$ = (x − z)$\mathbf{i}$ + (y − x)$\mathbf{j}$ + (z − xy)$\mathbf{k}$ using Stokes theorem around the triangle with vertices A(1,0,0), B(0,2,0) and C(0,0,1). 7

OR

20. (a) Use divergence theorem to find the volume of the cylindrical solid bounded by $x^2 + 4x + y^2 = 7$, $z = -1$, $z = 4$ given the vector field $\mathbf{F} = x\mathbf{i} + y\mathbf{j} + z\mathbf{k}$ across surface of the cylinder. 7

(b) Use Stokes theorem to evaluate $\int_c F.dr$ 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

B24ES1T01B	PROBLEM SOLVING AND PROGRAMMING TECHNIQUES (B)	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course shall prepare the student to write efficient and robust Python programs for solving computational problems. Through a combination of theoretical concepts and practical applications, students will explore the fundamentals of Python programming, including data types, control structures, and functions. The course will also cover essential libraries and frameworks used in engineering applications, emphasizing best practices in coding. By the end of the course, students will be equipped with the skills needed to implement algorithms, and develop programs meet engineering standards.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand fundamental computing concepts, including algorithms, pseudocode, flowcharts, and algorithmic problem-solving techniques. (Cognitive Knowledge Level: Apply)
CO 2	Develop proficiency in using Python's data structures, control flow statements, and loops to effectively manage and manipulate data. (Cognitive Knowledge Level: Apply)
CO 3	Acquire skills in defining and calling functions, using modules and packages, and working with Python's standard libraries to create modular and efficient code (Cognitive Knowledge Level: Apply)
CO 4	Learn file handling techniques in Python (Cognitive Knowledge Level: Apply)
CO 5	Utilize Python for mathematical computations and understand its role in data analysis. (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	3	3								1
CO 2	3	3	3								1
CO 3	3	3	3								1
CO 4	3	3	3								1
CO 5	3	3	3	3	2						1

Assessment Pattern

Bloom's Category	**Continuous Assessment**		**End Semester Examination (% Marks)**
	Test 1 (%Marks)	**Test 2 (%Marks)**	
Remember			
Understand	20	20	20
Apply	60	60	60
Analyse	20	20	20
Evaluate			
Create			

Mark Distribution

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

Continuous Internal Evaluation Pattern

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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), of 3 marks each and the student should answer all the questions. Part

B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1 (6 hours)

Introduction to programming languages : low level & high level, compiler, assembler, and interpreter.
Fundamentals of computing – Algorithms, pseudocode, flowchart, algorithmic problem solving.
Introduction to Python, brief history of Python, installing Python, IDE, Python coding introduction, keywords and Identifiers, Python statements, comments in Python, getting user input, variables, data types, numbers, strings, Python operators, precedence of operators.

MODULE 2 (8 hours)

Data Structures - Lists, Tuples, Dictionary.
Control flow and Operators Control flow and syntax, if statement, if-else statement, nested conditionals, logical operators, Loop in Python - while Loop, break and continue, for loop, pass statement

MODULE 3 (7 hours)

Function in Python - introduction of function, defining and calling a function, function arguments, built in function, scope of variables.
Modules and Packages – creating custom modules, importing modules, standard modules- sys, os, datetime, math, random, introducing Python packages – numpy, pandas, matplotlib.

MODULE 4 (5 hours)

File handling - files, and directories, modes for opening a file, reading data from a file, writing data to a file, saving a file, deleting an existing file, try and except, navigating directories using os and pathlib, creating and removing directories

MODULE 5 (10 hours)

Data analysis - overview of numpy and pandas, numpy – array creation, special arrays, indexing, slicing, reshaping, flattening, concatenation, splitting, using numpy for mathematical computations - element wise addition, subtraction, multiplication, division, statistical operations - mean, median, variance, standard deviation, matrix multiplication, basic functions - sin, cos, tan, exp, power, log, sum, product, min, max, broadcasting, logical operators, creating dataframes – from csv/txt file, data frame manipulation - indexing, selecting, filtering, saving a dataframe as csv/txt file, line plot and scatter plot using matplotlib, customizing plots.

Text Books

1. Allen B Downey, "Think Python", O'Reilly.
2. Wes McKinney, "Python for Data Analysis: Data Wrangling with Pandas, NumPy and IPython", Shroff/O'Reilly.

Reference Books

1. Charles Dierbach, "Introduction to Computer Science using Python", Wiley.
2. Yashavant Kanetkar, "Let Us Python", BPB Publications.
3. edX MOOC Course, "CS50 Introduction to Programming with Python".

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1	6
1.1	Introduction to programming languages – low level & high level, compiler, assembler, and interpreter.	1
1.2	Fundamentals of computing – Algorithms, pseudo code, flow chart, algorithmic problem solving.	2
1.3	Introduction to Python, brief history of Python, installing Python, IDE.	1
1.4	Python coding introduction, keywords and Identifiers, Python statements, comments in Python.	1
1.5	Getting user input, variables, data types, numbers, strings, Python operators, precedence of operators.	1
	Module 2	8
2.1	Data Structures - Lists, Tuples, Dictionary.	2
2.2	Control flow and Operators Control flow and syntax, if statement, if-else statement, nested conditionals, logical operators.	2
2.3	Loop in Python - while Loop, break and continue.	2
2.4	For loop, pass statement.	2
	Module 3	7
3.1	Function in Python - introduction of function, defining and calling a function, function arguments	2
3.2	Built in function, scope of variables.	1

3.3	Modules and Packages – creating custom modules, Importing Modules, standard modules- sys, os, datetime, math, random.	2
3.4	Introducing Python packages – numpy, pandas, matplotlib.	2
	Module 4	5
4.1	File handling - files, and directories	1
4.2	Modes for opening a file, reading data from a file, writing data to a file, saving a file, deleting an existing file, try and except.	2
4.3	Navigating directories using os and pathlib, creating and removing directories.	2
	Module 5:	10
5.1	Data analysis - overview of numpy and pandas .	1
5.2	Numpy – array creation, special arrays, indexing, slicing, reshaping, flattening, concatenation, splitting.	2
5.3	Numpy for mathematical computations - element wise addition, subtraction, multiplication, division.	2
5.4	Statistical operations - mean, median, variance, standard deviation, matrix multiplication.	1
5.5	Basic functions - sin, cos, tan, exp, power, log, sum, product, min, max, broadcasting.	1
5.6	Logical operators.	1
5.7	Creating dataframes – from csv/txt file, data frame manipulation - indexing, selecting, filtering, saving a dataframe as csv/txt file, line plot and scatter plot using matplotlib, customizing plots.	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1):

1. Discuss about pseudocode, algorithm, and a flow chart. What is the importance of writing an algorithm before writing the actual program?
2. Draw a flow chart to check if a given number is an Armstrong number.

Course Outcome 2 (CO 2):

1. Write a Python program that determines whether a given year is a leap year. Explain the logic used to make this determination
2. Write a Python program to calculate the factorial of a number using either a for loop or a while loop. Discuss why you chose the specific type of loop for this task.

Course Outcome 3 (CO 3):

1. How do Python modules and libraries simplify programming tasks? Provide examples of using a standard library to perform file handling operations.
2. Write a Python program to calculate the tax for an Indian citizen using both the old and new tax regimes. Utilize appropriate Python modules, libraries, and functions to structure your program.

Course Outcome 4 (CO 4):

1. How would you write a Python script to read data from a text file, process the data to remove any blank lines, and save the cleaned data to a new file?
2. How to check if a file exists in a particular directory? Give an error message if it doesn't exists.

Course Outcome 5 (CO 5):

1. How would you use NumPy to create an array of 10 random numbers and then convert it into a Pandas DataFrame?
2. Given a CSV file containing numerical data, explain how you would use NumPy and Pandas to calculate the mean and standard deviation of a specific column.

MODEL QUESTION PAPER

QP CODE: **Pages: 2**

Reg.No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: B24ES1T01B

Course Name: PROBLEM SOLVING AND PROGRAMMING TECHNIQUES(B)

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What is the main difference between a compiler and an interpreter?
2. What is the difference between a high-level programming language and a low-level programming language?
3. What is the main difference between a list and a tuple in Python?
4. How does a for loop differ from a while loop in Python?
5. What is the scope of a variable in Python?
6. How can you import a specific function from a module in Python?
7. How can you list all files in a directory using Python?
8. Discuss the various modes for opening a file?
9. How do you create a NumPy array with random integers between 1 and 10?
10. What is the primary purpose of the pandas library in Python?

PART B

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

11. Compare and contrast high level and low level programming languages. Discuss the advantages and disadvantages of each with examples and explain how a compiler, interpreter and assembler play a role in executing programs written in these languages.

OR

12. Describe the steps involved in solving a problem using an algorithmic approach. Write an algorithm to find the maximum number in a list, present it using both pseudocode and a flowchart. Write a code for the same in Python.

13. Explain the key differences between lists, tuples, and dictionaries in Python. Provide examples of scenarios where each data structure would be most appropriately used, and discuss how their unique properties affect performance and usability in a program.

OR

14. Discuss the control flow mechanisms in Python, including conditional statements and loops. Explain the role of logical operators within control flow, and demonstrate using a Python program how they can be used to find the factorial of a number.

15. Explain the concept of functions in Python, including the use of arguments and return values. Illustrate with examples how defining and calling functions can improve code organization and reusability, and discuss the importance of variable scope in function design.

OR

16. Describe how modules and packages are used in Python to manage code complexity. Explain the process of creating a custom module and importing standard libraries. Write a Python program to create an array of random numbers in the range 1 to 100 and find its mean, median and standard deviation by defining a function. You can use the standard libraries of Python.

17. Explain the process of reading from and writing to files in Python. Discuss the different modes of file access. Provide an example of a program that reads the names of 30 students and total marks scored from a user and save the data to a file after the entry is complete.

OR

18. Write a Python program to read the contents of file, replace a particular name in the file with another one and save the updated contents as a new file.

19. Describe the role of NumPy in data analysis. Explain how NumPy arrays differ from Python lists and demonstrate how NumPy can be used to perform efficient mathematical operations on large datasets.

OR

20. Explain how the pandas library is used for data manipulation and analysis in Python. Provide an example of loading a dataset into a pandas DataFrame, performing filtering, and discuss how pandas simplifies data analysis tasks.

B24ES1T07	FUNDAMENTALS OF ELECTRICAL ENGINEERING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course aims to provide the student with an understanding of the fundamental concepts of electrical circuits, DC and AC machines. It gives an overall concept about the fundamental principles of electric circuits, constructional details and characteristics of electrical machines. The course equips the students to apply the acquired knowledge to analyse the electric circuits, DC and AC electric machines.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the fundamental concepts of electric circuits and apply circuit laws to solve basic DC electric circuits. (Cognitive Knowledge Level: Apply)
CO 2	Analyse the characteristics of DC machines and select appropriate machines for different applications. (Cognitive Knowledge Level: Analyse)
CO 3	Understand the fundamental concepts of AC systems and analyse single-phase AC circuits with series combinations of R, L, and C. (Cognitive Knowledge Level: Analyse)
CO 4	Explain the working of transformers and induction motors and identify their applications. (Cognitive Knowledge Level: Apply)
CO 5	Describe the operation of alternators and BLDC motors and their applications. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes With Program Outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**
CO 1	3	3	2	2		2			1	1	1
CO 2	3	2	2	1		2			1	1	1
CO 3	3	3	2	2		3			1	1	1
CO 4	3	2	2	1		3			1	1	1
CO 5	3	2	2	1		3			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	20	20	20
Apply	20	40	30
Analyse	40	20	30
Evaluate			
Create			

Mark Distribution

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

Continuous Internal Evaluation Pattern

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1 (5 hours)

Introduction to Electrical Systems: Basic Terminology including Electric circuit, Voltage, Current, Power, Energy, Resistance, Inductance and Capacitance.

Analysis of DC electric circuits: Resistances in Series and Parallel combination – Current and Voltage division rules, Ohm's Law, Kirchoff's L aws. S olution o f E lectrical circuits using Mesh analysis

MODULE 2 (8 hours)

DC Generator: Construction, Working of a DC Generator, types of Armature windings, EMF equation, Types of DC Generators, Losses, Condition for maximum efficiency, Power flow d iagram, E fficiency, Arm ature rea ction (Co ncept only), Applications.

DC Motors: Principle of operation, Back emf, Necessity of Starters, Speed and Torque equation, Types of DC motor, Speed- Torque characteristics of Shunt and Series motors, Losses, Applications.

MODULE 3 (8 hours)

AC Fundamentals: Faraday's Laws of Electromagnetic Induction, Lenz's Law, Self-Inductance and Mutual inductance, Coefficient of coupling. (Concept and equations only). Generation of Alternating Voltages and Waveform, Frequency, Period, Average, RMS values, Form factor and Peak factor of Sine wave forms only. Phasor representation of sinusoidal quantities, Lagging and Leading Concepts. Rectangular and Polar representation of Phasors.
Analysis of Series RL, RC and RLC circuits with introduction to Power, Power factor, Active Power, Reactive Power and Apparent Power. Generation of Three Phase AC, Phase sequence, Comparison between Three phase and Single Phase, Line and Phase Values of Current and Voltage in Star and Delta connections.

MODULE 4 (9 hours)

Transformers: Types based on Construction, Principle of operation, EMF equation, Ideal Transformer, Losses, Efficiency, Condition for Maximum efficiency, Transformer ratings, Applications.
Three phase Induction motor: Construction, Classification, Rotating Magnetic Field, Principle of operation, Torque equation, Torque- Slip characteristics, Need of Starter, Starting using a Star Delta starter, Speed Control and Braking in Induction motors, Applications. Single phase Induction motors, Different types, Applications.

MODULE 5 (6 hours)

Three Phase Alternators: Construction details, Classification based on construction, Principle of operation, emf equation, Voltage regulation by direct method, Necessary conditions for the Parallel operation of Alternators, Applications.
BLDC motor: Construction, Principle of operation, Applications.

Text Books

1. B. L. Theraja, A. K. Theraja, Textbook of "Electrical Technology" Volume 1, S. Chand & Co., 2005.

2. D. P. Kothari and I. J. Nagrath, "Basic Electrical Engineering", 3rd Edition, Tata McGraw Hill, 2010.

3. V. K. Mehta & Rohit Mehta, "Principles of Electrical Engineering", S Chand Publishing, 2003.

4. J. B. Gupta, "Theory and Performance of Electrical Machines", S.K. Kataria & Sons, 2007.

5. R. K. Rajput, "Basic Electrical Engineering", Laxmi Publications, 2009.

6. D C Kulshreshtha, "Basic Electrical Engineering", Tata McGraw Hill, 2010.

Reference Books

1. C. L. Wadhwa, "Basic Electrical Engineering", New Age International Publisher, 2007.

2. S. K. Bhattacharya, "Basic Electrical and Electronics Engineering", Pearson Education India, 2011.

3. Del Toro V, "Electrical Engineering Fundamentals", Pearson Education, 2015.

4. A. Sudhakar, Shyammohan S.,"Circuits and Networks: Analysis and Synthesis "by McGraw-Hill, 2017.

5. Hayt W H, Kemmerly J E, and Durbin S M, "Engineering Circuit Analysis", Tata McGraw-Hill, 2013.

6. Hughes, "Electrical and Electronic Technology", Pearson Education, 2010.

COURSE CONTENTS AND LECTURE SCHEDULE

No	**{**Topic	**No of Lecture/Tutorial Hours**
	Module 1	**5**
1.1	**Introduction to Electrical Systems:** Basic Terminology including Electric circuit, Voltage, Current, Power, Energy, Resistance, Inductance and Capacitance.	1
1.2	**Analysis of DC electric circuits:** Resistances in Series and Parallel combination – Current and Voltage division rules, Ohm's Law, Kirchoff's Laws. Solution of Electrical circuits using Mesh analysis. Numerical problems.	4
	Module 2	**8**
2.1	**DC Generator:** Construction, Working of a DC Generator, types of Armature windings.	1
2.2	EMF equation, Types of DC Generators, Losses, Condition for maximum efficiency, Power flow diagram, Efficiency, Armature reaction (Concept only), Applications. Numerical Problems	4
2.3	**DC Motors:** Principle of operation, Back emf, Necessity of Starters. Speed and Torque equation, Types of dc motor, Speed- Torque characteristics of Shunt and Series motors, Losses, Applications. Numerical Problems	3
	Module 3	**8**

3.1	**AC Fundamentals:** Faraday's Laws of Electromagnetic Induction, Lenz's Law, Self-Inductance and Mutual inductance, Coefficient of coupling. (Concept and equations only).	1
3.2	Generation of Alternating Voltages and Wave form, Frequency, Period, Average and RMS values, Form factor and peak factor of Sine wave forms only. Phasor representation of sinusoidal quantities, Lagging and Leading Concepts. Rectangular and Polar representation of Phasors. Numerical problems	3
3.3	Analysis of Series RL, RC and RLC circuits with introduction to Power, Power factor, Active Power, Reactive Power and Apparent Power. Generation of Three Phase AC, Phase sequence, Comparison between Three phase and Single Phase, Line and Phase Values of Current and Voltage in Star and Delta connections. Numerical problems	4
	Module 4	**9**
4.1	**Transformers:** Types based on Construction, Principle of operation, EMF equation, Ideal Transformer, Losses, Efficiency, Condition for Maximum efficiency, Transformer ratings, Applications. Numerical problems	3
4.2	**Three phase Induction motor:** Construction, Classification, Rotating Magnetic Field, Principle of operation.	2
4.3	Torque equation, Torque- Slip characteristics, Need of Starter, Starting using a Star Delta starter, Speed Control and Braking in Induction motors, Applications. Single phase Induction motors, Different types, Applications. Numerical problems	4
	Module 5	**6**
5.1	**Three Phase Alternators:** Construction details, Classification based on construction, Principle of operation, emf equation, Voltage regulation by direct method, Necessary conditions for the Parallel operation of Alternators, Applications. Numerical problems	5
5.2	**BLDC motor:** Construction, Principle of operation, Applications.	1
	Total Hours	**36 Hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1):

1. Define the terms such as Voltage, Current, Power etc

2. Solve problems based on series/parallel network reduction method and current/Voltage division rule
3. Solve problems with Mesh analysis.

Course Outcome 2 (CO 2):

1. Describe the construction and Principle of working of DC Generator/Motor
2. Explain different types of DC Generator/Motor and its applications.
3. Problems on emf induced, speed, Torque etc

Course Outcome 3 (CO 3):

1. Explain Faraday's laws of Electromagnetic Induction, self-inductance, mutual inductance and coefficient of coupling etc.
2. Problems on rms and average values of sinusoidal waveforms
3. Analyze Series RL, RC, RLC ac circuits, Develop the relation between Line and Phase values of voltage and current in Star and Delta connections.

Course Outcome 4 (CO 4):

1. Describe the construction, principle of Operation of Transformers.
2. Problems on emf equation and efficiency of Transformer
3. Describe the construction and working of of Three phase Induction motor and its applications.
4. Explain a single-phase Induction motor and its applications.

Course Outcome 5 (CO 5):

1. Explain the construction, working principle and classifications of an Alternator.
2. Problems on the emf equation, Voltage regulation by direct method.
3. Explain the construction and working of BLDC motor.

MODEL QUESTION PAPER

QP CODE: **Pages: 3**

Reg.No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: B24ES1T07

Course Name: FUNDAMENTALS OF ELECTRICAL ENGINEERING

Max. Marks: 100 Duration: 3 hours

PART A

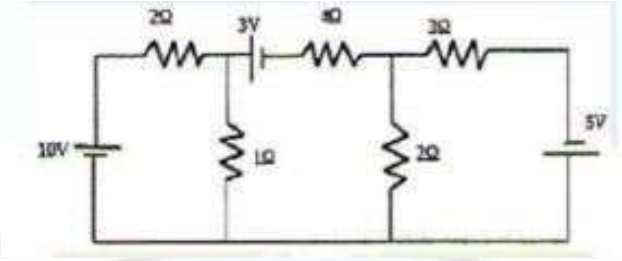
Answer all questions. Each question carries 3 marks.

1. Derive an expression for the energy stored in an inductor
2. Two coils connected in parallel across 100V supply mains take 10A from the line. The power dissipated in one coil is 600W. What is the resistance of the other coil?
3. Explain the necessity of starters in dc motors
4. Calculate the emf generated by 4 pole wave wound with 65 slots and 12 conductors/pole when driven at 1200rpm. Flux per pole is 0.02wb.
5. Define the following (a) cycle (b) time period (c) average value (d) rms value (e) peak factor (f) form factor.
6. State Faradays law of Electromagnetic Induction.
7. Derive the emf equation for a single-phase transformer
8. What is the effect of supply voltage on the torque of an induction motor?
9. What are the necessary conditions for parallel operation of an alternator?
10. List out the applications of BLDC motors.

PART B

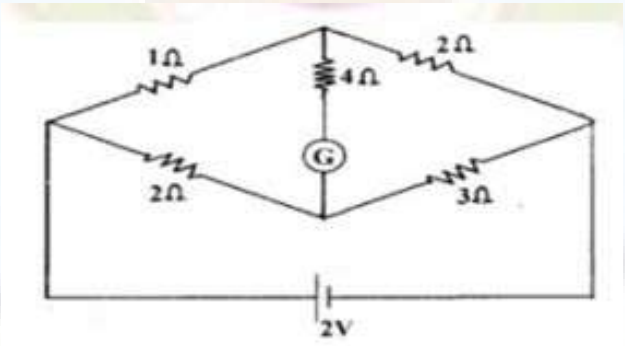
Answer any one question from each module. Each question carries 14 marks.

11. Calculate the node voltage in the circuit shown, applying node analysis



OR

12. State and explain Kirchhoff's laws. Calculate the current through the galvanometer G in the circuit shown



13. A 250V, 4 pole series motor has a two-circuit wave wound winding with 105 slots, each consisting of 12 conductors. The gap flux per pole is 0.02 wb when motor is on full load and taking a current of 45A. The armature and field resistances are 0.2Ω and 0.1Ω respectively. The iron and frictional losses are 700W. Calculate the (a) speed (b) shaft torque (c) bhp

OR

14. Two dc shunt generators with induced emfs of 120V and 115V, armature resistance of 0.05Ω and field resistances of 20Ω and 25Ω are in parallel suppling a total load of 25Kw. Calculate the load shared by each generator

15. Differentiate between statically and dynamically induced emf. A conductor of length 0.5m moves in uniform magnetic field of flux density 1.1T at a velocity of 30m/s. Calculate the emf induced in the conductor if the direction of motion of the conductor is inclined at an angle 60 to the direction of field.

OR

16. Derive the average value, rms value, amplitude factor and formfactor of a purely sinusoidal waveform.

17. A three phase, 50Hz induction motor has starting torque which is 1.25 times full load torque and a maximum torque which is 2.5 times full load torque. Neglecting stator resistance and rotational losses and assuming constant rotor resistance, find (i) the slip at full load (ii) slip at maximum torque and (iii) the rotor current at starting in per unit of full load rotor current.

OR

18. The primary and secondary windings of a 500Kva single phase transformer have resistance of 0.4Ω and 0.0015Ω. The primary and secondary voltages are 6000V and 400V and the iron loss is 3.2Kw. Calculate the efficiency on (a) full load (b) half load

19. With neat diagram, explain the construction and principle of operation of BLDC motors

OR

20. Discuss the constructional details of three phase alternators and classify them.

B24ES1T05B	BASIC CIVIL AND MECHANICAL ENGINEERING (B)	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	2	0	5	4	2024

Preamble

In pursuit of advancing knowledge and fostering a holistic understanding of engineering disciplines, this course on Basic Civil and Mechanical Engineering endeavors to provide students of Mechanical Engineering with a comprehensive insight into the fundamentals of both Civil and Mechanical Engineering. It seeks to empower students with the knowledge and skills necessary to contribute meaningfully to the advancement and innovation of Civil and Mechanical engineering practices, thereby meeting the evolving needs of society.

Prerequisites

Nil

Course Outcomes

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

CO 1	Recall the role of civil engineer in society and to relate the various disciplines of Civil Engineering.(Cognitive Knowledge Level: Understand)
CO 2	Discuss the Materials, energy systems, water management and environment for green buildings. (Cognitive Knowledge Level: Apply)
CO 3	Explain different types of buildings, building components, building materials and building construction. (Cognitive Knowledge Level: Apply)
CO 4	Understand the basic Thermodynamic concepts and Illustrate the working of IC engines.(Cognitive Knowledge Level: Understand)
CO 5	Understand the basic principle of power transmission elements and material handling devices. (Cognitive Knowledge Level: Understand)
CO 6	Describe the fundamentals of Refrigeration and air conditioning systems and basic knowledge on manufacturing and metal joining processes. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes With Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	1		1			3	2				2
CO 2	3	1	1		2	3					2
CO 3	3	2			2	1	1				2
CO 4	3	1	1			1			1		1
CO 5	3	1	2			1			1		1
CO 6	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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 5 marks

End Semester Examination Pattern

For the end semester examination, there will be two parts: Part I – Basic Civil Engineering and Part II – Basic Mechanical Engineering. Part I and PART II carries 50 marks each. Part I contain 2 parts - Part A and Part B. Part A contain 5 questions carrying 4 marks each (not exceeding 2 questions from each module). Part B contains 2 questions from each module out of which one to be answered. Each question carries 10 mark and can have maximum 2 sub-divisions. The pattern for end semester examination for part II is same as that of part I. **The student should answer both part I and part 2 in separate answer booklets.**

SYLLABUS
PART I– Basic Civil Engineering

MODULE 1 (9 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

Conventional construction materials : Types, properties and uses of building materials: bricks, stones, cement, sand, timber and steel. Cement concrete: Plain Cement Concrete (PCC) and Reinforced Cement Concrete (RCC), Constituent materials and properties (brief discussion only).

Other construction materials: Glass, Ceramics, Plastics, Composite materials, Thermal and acoustic insulating materials, Decorative panels, water proofing materials, Gypsum.

Surveying: Basic Principles of surveying, instruments, methods and measurements.

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

MODULE 2 (8 hours)

Components of a building: **Sub-structure** :Foundation- types of foundations- Shallow and deep, Machine foundation.

Super structure : Masonry: Brick masonry- Header and stretcher bond, English bond & Flemish bond-plan, elevation and isometric view, Stone masonry, Rubble masonry and Ashlar masonry.

Roof: Functions, types, and materials– flat roof, pitched roof, Shells and folded plates, Roof coverings for pitched roof-Thatch, Shingle, Tiles, Slates, Aluminium sheets, Galvanised iron (G.I.) sheets, Sandwich roof panels, roofing for industrial buildings.

Flooring: Functions, types of flooring - Mud, Brick, Flag stone, Cement concrete, Terrazzo, Mosaic, Marble, Tiles, Timber, Rubber, P.V.C.

Types of structures : Framed structures and load bearing wall structures. Pre-fabricated, pre-cast and modular construction. (brief discussion only).

MODULE 3 (6 hours)

Type of buildings : Classification of buildings based on occupancy as per NBC
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, KMBR & CRZ norms (brief discussion only), Selection of site-Site plan preparation for buildings as per Kerala Municipal Building Rules, general provisions regarding site and building requirements.
Green buildings: Materials, energy systems, water management and environments for green buildings. (brief discussions only)

PART II– Basic Mechanical Engineering

MODULE 4 (8 hours)

Basics of thermodynamics: State, Process, Cycle, System and control volume concept, Enthalpy and Entropy, Types of thermodynamic processes, thermodynamic laws, Carnot, Otto and Diesel cycles, Efficiency, Heat addition and rejection, Problems
I.C Engines: Working of SI and CI engine, Two stroke and Four stroke engine, IC engine parts, Fuel, Cooling and Lubrication systems, CRDI and MPFI engines. Concept of hybrid engines.

MODULE 5 (7 hours)

Power Transmission Elements Classification and applications of mechanical drives, Velocity ratio of belt drive, Length of belt, Slip in belt, Power transmitted. Gear drive: Types, Gear Ratio, Simple, compound and epicyclic gear trains (simple descriptions only)
Automotive Drives: Manual Transmission, Automatic Manual Transmission (AMT), Continuous Variable Transmission (CVT), Torque converter.

MODULE 6 (8 hours)

Refrigeration : Basic terminologies, Vapour Compression Refrigeration system with PH and TS diagram, Air conditioning- Summer and winter air conditioning, Unitary and central air conditioning system, Inverter technology.
Basic description of the manufacturing processes: (Basic Concepts only and examples of products) – Die Casting, Forging, Rolling, Extrusion. Basic description of Lathe and Drilling Machine, Lathe operations. Basic description of Metal Joining Processes: Arc and gas Welding, Soldering and Brazing, their applications

Text Books

1. S. C. Rangwala, “Civil Engg. Drawing”, Charotar Pub. House Anand.
2. B. C. Punamia, “Surveying Vol .I & II”, Laxmi Publication Delhi.

3. J. Benjamin, "Basic Mechanical Engineering", Pentex Books, 9th Edition, 2018
4. P. Balachandran, Basic Mechanical Engineering, Owl Books

Reference Books

1. R. Chudley, "Construction Technology Vol. I to IV", Longman Group, England (2011).
2. R. Chudley and R. Greeno, "Building Construction Handbook", Addison Wesley, Longman Group, England (1998).
3. M. S. Mamlouk, and J. P. Zaniewski, "Materials for Civil and Construction Engineering", Pearson Publishers (2011)
4. W.B. McKay and J.K. McKay, "Building Construction Vol. 1 to 4", Pearson India Education Services. (2013)
5. S. C. Rangwala and K.B. Dalal, Building Construction, Charotar Publishing House (2017).
6. Kerala Municipal Building Rules (latest revision)
7. M. Clifford, K. Simmons, "An Introduction to Mechanical Engineering Part I", CRC Press
8. Roy and Choudhary, "Elements of Mechanical Engineering", Media Promoters &Publishers Pvt. Ltd., Mumbai.
9. G. S. Sawhney, "Fundamentals of Mechanical Engineering", PHI
10. M.S. Shanmugam, Palanichamy, "Basic Civil and Mechanical Engineering", McGraw Hill Education; First edition, 2018

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No of Lecture/Tutorial Hours
	Module 1	**9**
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 .	2

1.2	Conventional construction materials: types, properties and uses of building materials: bricks, stones, cement, sand, timber and Steel. Cement concrete: Plain Cement Concrete (PCC) and Reinforced Cement Concrete (RCC), Constituent materials and properties (brief discussion only).	2
1.3	Other construction materials: Glass, Ceramics, Plastics, Composite materials, Thermal and acoustic insulating materials, Decorative panels, water proofing materials, Gypsum .	2
1.4	Surveying: Basic Principles of surveying, instruments, methods and measurements	1
1.5	Environment: Water Supply and Sanitary Systems, Urban Air Pollution Management, Solid Waste Management, Urban Flood Control (brief discussion only).	2
	Module 2	**8**
2.1	Components of a building: Sub-structure: Foundation-types of foundations- Shallow and deep, Machine foundation .	2
2.2	Super structure: Masonry: Brick masonry- Header and stretcher bond, English bond & Flemish bond-plan, elevation and isometric view, Stone masonry, Rubble masonry and Ashlar masonry.	2
2.3	Roof: Functions, types and materials– flat roof, pitched roof, Shells and folded plates, Roof coverings for pitched roof-Thatch, Shingle, Tiles, Slates, Aluminium sheets, Galvanised iron (G.I.) sheets, Sandwich roof panels, roofing for industrial buildings.	2
2.4	Flooring: Functions, types of flooring - Mud, Brick, Flag stone, Cement concrete, Terrazzo, Mosaic, Marble, Tiles, Timber, Rubber, P.V.C.	1
2.5	Types of structures: Framed structures and load bearing wall structures. Pre-fabricated, pre-cast and modular construction. (brief discussion only).	1
	Module 3	**6**
3.1	Type of buildings: Classification of buildings based on occupancy as per NBC.	1
3.2	Building area: Plinth area, built-up area, floor area, carpet area and floor area ratio for a building as per KMBR.	2
3.3	Building rules and regulations: Relevance of NBC, KMBR & CRZ norms (brief discussion only), Selection of site-Site plan preparation for buildings as per Kerala Municipal Building Rules, general provisions regarding site and building requirements.	2
3.4	Green buildings: Materials, energy systems, water management and environments for green buildings.(brief discussions only)	1
	Module 4	**8**

4.1	Basics of thermodynamics: State, Process, Cycle, System and control volume concept,Enthalpy and Entropy, Types of thermodynamic processes.	1
4.2	Carnot, Otto and Diesel cycles, Efficiency, Problems	2
4.3	Working of SI and CI engine, Two stroke and Four stroke engine, IC engine parts.	2
4.4	Fuel, Cooling and Lubrication systems, CRDI and MPFI engines.	2
4.5	Concept of hybrid engines.	1
	Module 5	**7**
5.1	Power Transmission Elements: Classification and applications of mechanical drives.	1
5.2	Velocity ratio of belt drive.	1
5.3	Length of belt, Slip in belt, Power transmitted. Gear drive: Types, Gear Ratio, Simple, compound and epicyclic gear trains (simple descriptions only)	3
5.4	Automotive Drives: Manual Transmission, Automatic Manual Transmission (AMT), Continuous Variable Transmission (CVT), Torque converter.	2
	Module 6	**8**
6.1	Refrigeration, Air conditioning, Vapour Compression Refrigeration system, Summer and winter air conditioning.	2
6.2	Basic description of the manufacturing processes (Basic Concepts only and examples of products)	1
6.3	Die Casting, Forging, Rolling, Extrusion.	2
6.4	Basic description of Lathe and Drilling Machine, Lathe operations.	1
6.5	Basic description of Metal Joining Processes: Arc and gas Welding, Soldering and Brazing, their applications.	2
	Total Hours	**46 Hours**

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. Compare and contrast the characteristics and purposes of residential, commercial, and industrial buildings.
2. Discuss the importance of building components in the construction process.
3. How have innovations in techniques influenced the efficiency, sustainability, and safety of construction practices?

Course Outcome 4 (CO 4):

1. Describe the working of a four-stroke diesel engine.
2. Why two stroke engines are less efficient than four stroke engine?
3. In an Isothermal process, Why does the temperature remains constant despite the heat exchange?

Course Outcome 5 (CO 5):

1. Derive an expression to determine the length of an open belt drive
2. Explain the working of CVT system.
3. What are the advantages of AMT Vehicles?.

Course Outcome 6 (CO 6):

1. With the aid of a neat sketch, explain the working of a Vapour Compression Refrigeration system.
2. List the commonly used metal joining processes in manufacturing.
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 ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: B24ES1T05B

Answer both part I and part 2 in separate answer booklets

Course Name: BASIC CIVIL AND MECHANICAL ENGINEERING

Max. Marks: 100 Duration: 3 hours

Answer both part I and part 2 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 affect the safety and reliability of equipment?
3. Elaborate on how the Floor Area Ratio (FAR) is determined for a building
4. Compare load-bearing masonry structures and framed structures.
5. Provide examples of machinery foundation types and their applications in various industrial settings.

PART B

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

Module 1

6. Provide a concise overview of the basic principles, instruments, methods, and measurements involved in surveying. 10

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

Module 2

8. How do green buildings incorporate sustainable practices in terms of materials, energy systems, water management, and overall environmental considerations? 10

OR

9. Explain the essential components of a residential building and elaborate on their functions within the functionality of the structure. 10

Module 3

10. Elaborate on the structural characteristics and load-bearing capabilities of brick masonry, stone masonry, and rubble masonry. 10

OR

11. (a) What advantages do steel trusses offer in terms of strength, span capabilities, and cost-effectiveness? 6

    (b) How do industrial roofing requirements differ from those of residential structures, and what specific roofing materials are commonly used in industrial buildings? 4

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 velocity ratio in belt drive.
4. Explain Arc welding and Gas welding with suitable sketches.
5. Define: Casting and forging processes.

PART B

Answer all questions. Each question carries 10 marks

Module 4

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

OR

7. Derive the air standard efficiency of Diesel Cycle 10

Module 5

8. (a) What are the different modes of power transfer? 5
   (b) What is slip in belt drive? Why it is an undesirable effect? 5

OR

9. (a) Explain the working of a torque convertor. 4
   (b) Compare manual and automatic transmission in automobiles 6

Module 6

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

OR

11. With a neat sketch, Explain the different components of a Lathe. 10

B24ME1T01	ENGINEERING GRAPHICS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	2	4	4	2024

Preamble

This course aims at equipping students with the ability to communicate technical concepts through global-standard graphical representation. Students learn to interpret existing engineering drawings accurately and convey design information effectively. Emphasis is placed on mastering graphical communication techniques to meet industry standards. By the end of the course, students will have the skills to articulate complex engineering information visually and interpret engineering drawings with precision.

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	Prepare pictorial drawings using the principle of isometric projections and convert 3D views to orthographic views. (Cognitive Knowledge Level: Analyse)
CO 5	Prepare pictorial drawings using the principle of perspective projections.(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	2			1		1		1
CO 2	3	2	2	2			1		1		1
CO 3	3	2	2	2			1		2		1
CO 4	3	2	2	2			1		2		1
CO 5	3	2	2	2			1		2		1

Assessment Pattern

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

Mark Distribution

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

Continuous Internal Evaluation Pattern

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 5 marks

End Semester Examination Pattern

ESE will be of 3-hour duration on A4 size answer booklet and will be for 100 marks. The question paper shall contain two questions from each module. Student has to answer any one question from each module. Each question carries 20 marks

SYLLABUS

MODULE 1 (12 hours)

Introduction: Relevance of technical drawing in engineering field. Types of lines, Dimensioning, BIS code of practice for technical drawing.
Orthographic projection of Points and Lines: Projection of points in different quadrants, Projection of straight lines inclined to one plane and inclined to both planes. Trace of line. Inclination of lines with reference planes True length of line inclined to both the reference planes.

MODULE 2 (12 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 with axis inclined to both reference planes.

MODULE 3 (11 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. Also locating the section plane when the true shape of the section is given.
Development of Surfaces: Development of surfaces of the above solids and solids cut by different section planes. Also finding the shortest distance between two points on the surface.

MODULE 4 (10 hours)

Isometric Projection: Isometric View and Projections of Prisms, Pyramids, Cone, Cylinder, Frustum of Pyramid, Frustum of Cone, Sphere, Hemisphere and their combinations.
Conversion of Pictorial Views: Conversion of pictorial views into orthographic views.

MODULE 5 (10 hours)

Perspective Projection: Perspective projection of Prisms and Pyramids with axis perpendicular to the ground plane and axis perpendicular to picture plane.
Intersection of surfaces: Methods of determining lines of intersection - Intersection of prism in prism and cylinder in cylinder.

Text Books

1. Bhatt, N.D., Engineering Drawing, Charotar Publishing House Pvt. Ltd.

2. John, K.C. Engineering Graphics, Prentice Hall India Publishers.

3. K.N. Anilkumar, Engineering Graphics, Adhyuth Narayan Publishers.

4. P I. Varghese, Engineering Graphics, VIP Publishers

Reference Books

1. Agrawal, B. and Agrawal, C.M., Engineering Drawing, Tata McGraw Hill Publishers.

2. Duff, J.M. and Ross, W.A., Engineering Design and Visualisation, Cengage Learning.

3. Kulkarni, D.M., Rastogi, A.P. and Sarkar, A.K., Engineering Graphics with AutoCAD, PHI.

4. Luzaddff, W.J. and Duff, J.M., Fundamentals of Engineering Drawing, PHI.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No of Lecture/Tutorial Hours
	Module 1	**12**
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 principal 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	3
	Module 2	**12**
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	4
2.4	Practice problems on solids inclined to both planes	3
	Module 3	**11**
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	4
3.3	Principle and development of simple solids	2
3.4	Development of solids and sectioned solids	3
	Module 4	**10**
4.1	Principle of Isometric View and Projection, Isometric Scale. Problems on simple solids	2
4.2	Isometric problems on Frustum of solids, Sphere and Hemisphere	3
4.3	Problems on combination of different solids	3
4.4	Practice on conversion of pictorial views into orthographic views	2
	Module 5	**10**
5.1	Introduction to perspective projection, different planes, station point etc. Perspective problems on pyramids	2
5.2	Perspective problems on prisms	4
5.3	Intersection of surfaces: methods of determining lines of intersection - intersection of prism in prism and cylinder in cylinder.	4
	Total Hours	**54 Hours**

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 Isometric views/projections of solids
2. Draw Isometric views/projections of combination of solids
3. Draw Orthographic views of solids from given three-dimensional view

Course Outcome 5 (CO 5):

1. Draw Perspective views of Solids
2. Draw Intersection of surfaces of two identical solids

MODEL QUESTION PAPER

QP CODE: **Pages: 2**

Reg.No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: B24ME1T01

Course Name: ENGINEERING GRAPHICS

Max. Marks: 100 Duration: 3 hours

Answer any one question from each module. Each question carries 20 marks

Instructions: Retain construction lines. Show necessary dimensions

Module I

1. The end point A of a line is 20mm above HP and 10mm in front of VP. The other end of the line is 50mm above HP and 15mm behind VP. The distance between the end projectors is 70mm. Draw the projections of the line. Find the true length and true inclinations of the line with the principal planes. Also locate the traces of the line.
2. One end of a line is 20mm from both the principal planes of projection. The other end of the line is 50mm above HP and 40mm in front of VP. The true length of the line is 70mm. Draw the projections of the line. Find its apparent inclinations, elevation length and plan length. Also locate its traces.

Module II

3. A pentagonal pyramid of base side 25mm and height 40mm, is resting on the ground on one of its triangular faces. The base edge of that face is inclined 30^0 to VP. Draw the projections of the solid.
4. A hexagonal prism has side 25mm and height 50mm has a corner of its base on the ground and the long edge containing that corner inclined at 30^0 to HP and 45^0 to VP. Draw the projections of the solid.

Module III

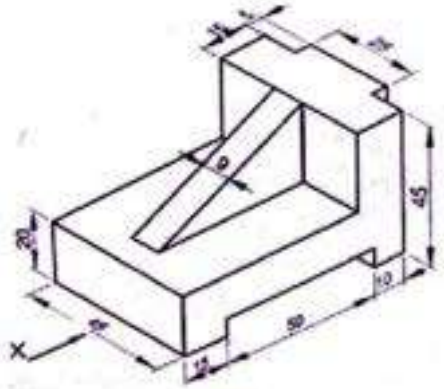
5. A triangular prism of base side 40mm and height 70mm is resting with its base on the ground and having an edge of the base perpendicular to VP. Section the solid such that the true shape of the section is a trapezium of parallel sides 30mm and 10mm. Draw the projections showing the true shape. Find the inclination of the cutting plane with the ground plane

6. Draw the development of a pentagonal pyramid of base side 30mm and height 50mm. A string is wound from a corner of the base round the pyramid and back to the same point through the shortest distance. Show the position of the string in the elevation and plan.

Module IV

7. The frustum of a cone has base diameter 50mm and top diameter 40mm has a height of 60mm. It is paced centrally on top of a rectangular slab of size 80x60mm and of thickness 20mm. Draw the isometric view of the combination.

8. Draw three orthographic views with dimensions of the object shown in figure below.



Module V

9. Draw the perspective view of a pentagonal prism, 20mm side and 45mm long lying on one of its rectangular faces on the ground and having its axis perpendicular to picture plane. One of its pentagonal faces touches the picture plane and the station point is 50mm in front of PP, 25mm above the ground plane and lies in a central plane, which is 70mm to the left of the center of the prism.

10. A square prism 50mm side and height 100 mm stands vertically with its base on HP with two of its adjacent rectangular faces inclined equally to VP. Another horizontal square prism of the same size penetrates the vertical prism such that the axes of the two prisms bisects each other at right angles. If the two adjacent faces of the horizontal prism are inclined equally to HP, draw the projections showing the lines of intersections.

B24ES1L04B	BASIC CIVIL AND MECHANICAL WORKSHOP	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	2	1	1	2024

Preamble

The aim of this course is to help students to gain practical knowledge with a correlation to theoretical studies and encourage them to understand physical problems. Students will demonstrate an understanding of various disciplines of civil and mechanical engineering while acquiring hands-on training with various tools and processes. The course is designed to train students to identify and manage the tools, materials, and methods required to execute an engineering project.

Prerequisite

NIL

Course Outcomes

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

CO 1	Identify and select appropriate plumbing materials for different applications and Familiarize with a range of building materials, their properties, and applications in construction. (Cognitive Knowledge Level: Apply)
CO 2	Develop proficiency in using standard measuring tape and digital distance measuring devices to accurately calculate the area of built-up spaces and small parcels of land and compute the area and or volume of various features in a structure. (Cognitive Knowledge Level: Apply)
CO 3	Develop skills in drawing foundation plans, indicating wall thickness and foundation width, emphasizing the importance of accurate planning in construction. (Cognitive Knowledge Level: Analyse)
CO 4	Identify and use various tools in carpentry & sheet metal work and perform multiple operations for the preparation of joints using wood and fabrication using sheet metal. (Cognitive Knowledge Level: Apply)
CO 5	Identify and use various tools in smithy & foundry and to practice forging, moulding, and casting. (Cognitive Knowledge Level: Apply)
CO 6	Identify and use various tools used in fitting and welding and perform operations such as chipping, filing, cutting, drilling, etc., and prepare multiple joints and welds. (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	1	2
CO 2	3	3	2		2	1		3	1	1	3
CO 3	3	3	2		2	1		3	1	1	3
CO 4	1	1	1					2	1	1	2
CO 5	1	1	1					2	1	1	2
CO 6	1	1	1					2	1	1	2

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
100	70	30	1 hours

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 1

CIVIL WORKSHOP

Sl.No.	Topic
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	Prepare line sketch of a building showing the position of doors, windows and ventilators
6	Prepare the foundation plan (not to scale) of a small single storey building showing its cross section.

Reference Books

1. J. Paul Guyer," Plumbing Engineering Services Design Guide"
2. S. K. Duggal, "Building Materials", New Age International, 2019.
3. B. N. Dutta," Estimating and Costing in Civil Engineering", UBS Publishers, 2016.
4. Ralph B. Peck, Walter E. Hanson, Thomas H. Thornburn, "Foundation Engineering", John Wiley & Sons
5. Varghese P.C, "Design of Reinforced Concrete Foundations", PHI, 2009.
6. J.L. Meriam and L.G. Kraige, "Engineering Mechanics: Statics", John Wiley & Sons, 2017.
7. S. Timoshenko and D.H. Young, "Engineering Mechanics", McGraw Hill Education, 2017.

PART 2

MECHANICAL WORKSHOP

(Five models from exercises 1 to 8 are mandatory. Additionally, the study and demonstration of the remaining exercises are also required.)

Sl.No.	Topic
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	Sheetmetal: - Study of sheet metal tools, Forming and joint practices: Cylindrical shape, Conical shape, Rectangular Tray
3	Smithy: - Study of different tools & forged models in Smithy shop, Forging Practices: Square prism, Hexagonal headed bolt, octagonal prism
4	Foundry: - Study of Foundry tools, Molding practices: Bench molding, Floor molding, Core making, Casting
5	Fitting: - Study of Fitting tools in a workshop, Fitting shop joints practices: Square Joint, V-Joint, Male and Female fitting
6	Welding: - Study of Welding tools, equipment's and methods, Welding practices: Arc Welding, MIG Welding, Oxy-Acetylene Gas Welding
7	Conventional Machines: Study and demonstration of conventional machines like Shaping and Slotting machine, Lathe, Milling machine, Grinding machines & Radial drilling machine
8	Advanced Manufacturing Methods: Study and demonstration of CNC machines and 3D printing

Reference Books

1. Chapman, W. A. J, Workshop Technology - Parts 1 and 2, 4^{th} ed., New Delhi, India, CBS Publishers & Distributors Pvt. Ltd, 2007.
2. O'Bren, A. (Editor), Welding Handbook. 9^{th} ed., Miami, American Welding Society, 2001.
3. Anderson, J., Shop Theory, New Delhi, India, Tata McGraw Hill, 2002.
4. Douglass, J. H., Wood Working with Machines, Illinois, McKnight & McKnight Pub. Co., 1995.
5. Tuplin, W. A., Modern Engineering Workshop Practice, Odhams Press, 1996.
6. Jain, P. L., Principles of Foundry Technology, 5^{th} ed., New Delhi, India, Tata McGraw Hill, 2009.
7. S.K. Hajra Choudhury, Workshop Technology Vol II, Media Promoters & Publishers, 2010.

B24ES1L01B	PROGRAMMING LAB (B)	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

This course introduces students to problem-solving using Python programming, offering hands-on experience with core concepts such as data types, control structures, functions, file handling, and data analysis. By engaging in practical exercises, students will develop the skills necessary to analyse complex engineering problems and implement effective solutions using Python.Upon completing this course, students will be equipped to apply Python to real-world engineering challenges, enhancing their computational thinking and technical proficiency.

Prerequisite

Nil

Course Outcomes

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

CO 1	Use fundamental Python constructs to solve basic computational problems (Cognitive Knowledge Level: Apply)
CO 2	Solve problems using data structures, logical conditions, and control loops enhancing their problem-solving skills (Cognitive Knowledge Level: Apply)
CO 3	Create functions and use inbuilt Python libraries to perform calculations and solve practical problems (Cognitive Knowledge Level: Apply)
CO 4	Manage and manipulate files and directories in Python (Cognitive Knowledge Level: Apply)
CO 5	Manipulate data using fundamental Python packages/libraries to perform mathematical operations and statistical analysis (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	3	3								1
CO 2	3	3	3								1
CO 3	3	3	3								1
CO 4	3	3	3								1
CO 5	3	3	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 Evaluation	
• Class work/ Assessment	: 10 marks
• Viva (Self Study)	: 10 marks
Viva voce / test	: 15 marks
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

18 experiments from the following list of experiments are mandatory. At least 3 questions should be given from each set. The study and discussion of the remaining are also required.

	SET 1
1	Write a Python program to swap the values of two variables without using a third variable.
2	Write a Python program that accepts a single numeric parameter representing an angle in radians to convert into degree.
3	Implement a Python program that calculates simple interest based on user input for the principal amount, rate of interest, and time.
4	Create a Python program that takes a single character input and determines whether it is a vowel or consonant.
5	Write a Python programme to solve a quadratic equation. The inputs shall be taken from the user.
	SET2
6	Write a Python program to find the first n prime numbers.
7	Write a Python program to check if a given year is a leap year

8	Write a Python program to read a string (word), store it in an array and check whether it is a palindrome.
9	Create a program that takes a tuple of numbers, converts it to a list, adds a new element, and then converts it back to a tuple.
10	Write a program to create a dictionary with student names as keys and their scores as values. Implement a search feature to find a student's score by name.
	SET 3
11	Write a function that returns the n^{th} Fibonacci number. Test the function with various values of n.
12	Write a program that simulates rolling a six-sided die 10 times and prints the result of each roll using the random module.
13	Create a custom module named `math_utils.py` with a function factorial(n) that returns the factorial of a number n. Import this module in a script and use the factorial() function.
14	A person needs to file his Income Tax Returns. He doesn't know if new regime or the old regime is beneficial. Please help him out by writing a Python program asking him the gross salary and possible deductions. You may use functions and Python libraries.
15	Write a Python function that takes two parameters: a list of numbers and a second parameter that can have one of three values: "asc", "desc", or "none". If the second parameter is "asc", the function should return the list of numbers in ascending order. If it is "desc", the function should return the list of numbers in descending order. If the second parameter is "none", the function should return the unaltered list.
	SET 4
16	Write a program that finds and prints the longest line in the file 'lines.txt'. The file will be kept in a prescribed directory.
17	Write a program that writes a list of dictionaries to a CSV file 'output.csv' and text file 'output.txt' both in a folder named 'data'.
18	Write a Python program that lists all the files in the current directory.
19	Write a Python program that searches for a specific word in a file and replaces it with another word. The program should save the changes to the same file. Also count the number of words replaced.
20	Reads the first 5 lines from an existing text file using the readline() method. If the file doesn't exist, handles the error using try and except, and creates a new file with the same name. Writes user input line by line into the file until the user decides to stop, ensuring the file is properly saved.
	SET 5
21	Create a NumPy array with random integers between 0 and 100 of size 5x5. Compute and print the mean, median, standard deviation, and sum of all elements. Find the row wise and column wise sum of the elements of the matrix. Perform matrix multiplication and display the result along with the multiplied ones. Find the element wise product, sum and difference find the sum of squares of all the elements row wise and display the result.

22	Read a csv file where the details of students and their marks obtained in various subjects are given. Remove the students from the list who is absent for any one of the exams where it displays 'abs' against the subject. Find the percentage of marks for each student and add it as the last column and save the updated file in a new name. Also display the names of students that scored more than 80% marks.
23	Load a CSV file containing sales data with columns for product name, quantity sold, and price. Calculate the total sales revenue for each product and identify the product with the highest revenue.
24	Generate a 10x10 matrix of random integers, extract all even numbers, and replace them with their negative values and all odd numbers to double their values. Find the minimum and maximum elements in the matrix.
25	Generate a line plot of the sine and cosine functions from 0 to 2π using Matplotlib. Give a title, label the axes and add a legend. Save the plot. Try the same for a scatter plot.

Reference Books

1. Eric Matthes, "Python Crash Course", No Starch Press
2. Cay S Horstmann, Rance D Necaise, "Python For Everyone", Wiley
3. Guttag John V, "Introduction to Computation and Programming using Python", PHI
4. Kenneth A Lambert, "Fundamentals of Python: First Programs", Cengage

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: Analyze)
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
CO1	1	1				2	2	3	2	2	2
CO2	1	1				2	3	3	2	2	2
CO3	1	1				2	2	3		3	2
CO4	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"; First Edition; Wiley Publishing Ltd, 2015.

6. Larry James, "The First Book of Life Skills"; First Edition, Embassy Books, 2016.

7. Shalini Verma, "Development of Life Skills and Professional Practice"; First Edition; Sultan Chand (G/L) Company, 2014.

8. Daniel Goleman, "Emotional Intelligence"; Bantam, 2006.

9. Remesh S., Vishnu R.G., "Life Skills for Engineers", Ridhima Publications, First Edition, 2016.

10. Butterfield Jeff, "Soft Skills for Everyone", Cengage Learning India Pvt Ltd; 1 edition, 2011.

11. Training in Interpersonal Skills: Tips for Managing People at Work, Pearson Education, India; 6 editions, 2015. Ace of Soft Skills: Attitude, Communication and Etiquette for Success, Pearson Education; 1 edition, 2013

12. Prasanna Chandra, "Fundamentals of Financial Management", McGraw Hill Education (India) Private Ltd,2020

13. Edward de Bono, "Lateral Thinking"

14. 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 hour
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 ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: B24MC1T01

Course Name: LIFE SKILLS

Max. Marks: 50 Duration: 2 hours

PART A

Answer all questions. Each question carries 5 marks.

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

PART B

Read carefully the following case and answer the questions given below. Each question carries 6 marks.

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

   (a) Critique the communication strategy (or lack thereof) employed by UCIL during the disaster. How did the absence of timely warnings and information affect the outcome?

   (b) Assess the ethical implications of UCIL's decision to build a pesticide plant in a densely populated area. How should corporate responsibility have been exercised in this context?

   (c) As an engineer, comment on the drawback of the design which may have the reason for the tragedy.

   (d) Evaluate the leadership displayed by UCIL's management during the Bhopal disaster. How did their response, or lack thereof, impact the outcome of the crisis?

   (e) Reflect on the lessons learned from the Bhopal disaster. What key takeaways should industries and governments derive from this incident to enhance safety and prevent future catastrophes?

B24MC1T02	DESIGN THINKING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		1	1	0	2	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 de-sign thinking methodology. (Cognitive Knowledge Level: Understand)
CO 2	Utilize diverse techniques effectively to generate creative concepts, adopting in-novation 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
CO1	2	1	3	1	1	1	1	2	1	1	1
CO2	2	2	3	1	1	1	1	2	1	1	1
CO3	2	2	3	1	1	1	1	2	1	1	1
CO4	2	2	3	1	1	1	1	2	1	1	1

Assessment Pattern Assessment Pattern

Bloom's Category	**Continuous Assessment**		**End Semester Examination (% Marks)**
	Test (%Marks)	**Case Study Presentation (Marks) (%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 Tamer M Shahin, "Engineering design process", Course Technology, 2010.
2. Clive L Dym, Patrick Little Elizabeth J Orwin, "Engineering Design-A Project based Introduction", Wiley, 2014.
3. Don Norman, "The Design of Everyday Things", Basic Books; 2nd edition, 2013.
4. Christian Mueller-Roterberg, "Handbook of Design Thinking: Tips and Tools for how to design thinking", 2018.

Reference Books

1. Daniel Kahneman, "Thinking Fast and Slow", Farrar, Straus Giroux, 201.
2. Rod Judkins, "The art of Creative Thinking", Penguin Publishing Group, 2016.

3. Donella H Meadows, “Thinking in Systems”, Chelsea Green Publishing, 2008.

4. Tim Brown, “Change by Design”, HarperCollins, 2019.

5. V.N.Mittle & Arvind Mittal, ”Basic Electrical Engineering ” 2^{nd} Edition, McGraw Hill, 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 Desing 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 ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: B24MC1T02

Course Name: DESIGN THINKING

Max. Marks: 50 Duration: 2 hours

PART A

Answer all questions. Each question carries 5 marks.

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

PART B

Answer any one question from each module.

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

OR

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

OR

8. Identifyl the customer requirements with the help of refrigerator as example, 8

9. How concepts evaluation can be done using Pugh's evaluation matrix. Compare Pugh's evaluation matrix with the decision matrix. 7

OR

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

11. Design a device/machine that will crush aluminum cans. The device must be fully automatic. The device should switch on automatically, crush the can automatically, eject the crushed can automatically and switch off automatically. 7

OR

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

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

Preamble

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

Prerequisites

Nil

Course Outcomes

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

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 Lifestyle:

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

MODULE 2 (6 hours)

Physical fitness a nd exercise:

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

MODULE 3 (6 hours)

First aid:

First aid and principles of first a id.First a id m easure f or t he f ollowing: B leeding through Nose, Snakebite, Dog Bite, Electric Shock, Burns and Drowning.Common injuries and their management: Wounds, Cuts, Sprain, Fracture and Dislocation. Cardio Pulmonary Resuscitation (CPR).How to prevent muscle cramps and its management.How to carry an injured person.

MODULE 4 (6 hours)

Postures and nutrition:

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

Text Books

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

Reference Books

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

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No of Lecture/Tutorial Hours
	Total Hours	24 Hours
	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 co ordinative abilities	1
2.3	Exercises to prevent back pain, shoulder injury and knee pain.	2
2.4	Fitness test battery for speed, strength, endurance, flexibility.	1
2.5	Importance of weight training, Warming up and cooling down.	1
	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):

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):

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

MAR ATHANASIUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution
Kothamangalam, Kerala, India

B.TECH MECHANICAL ENGINEERING

SEMESTER 2

SYLLABUS

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

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	1	1									
CO 2	1	1				1					
CO 3	1	1			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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 5 marks

End Semester Examination Pattern

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

SYLLABUS

MODULE 1 (Ordinary Differential Equations)

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

Homogenous linear differential equation of second order, superposition principle, general solution, homogenous linear ODEs with constant coefficients-general solution. Solution of Euler-Cauchy equations (second order only). Existence and uniqueness (without proof). Non

homogenous linear ODEs-general solution, solution by the method of undetermined coefficients(for the right hand side of the form x^n,e^{kx},$sinax$, $cosax$ and their linear combinations) , methods of variation of parameters. Solution of higher order equations-homogeneous and non-homogeneous with constant coefficients using method of undetermined coefficients.

MODULE 2 (Sequences and Series)

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

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

MODULE 3 (Fourier Series)

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

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

MODULE 4 (Fourier Transforms)

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

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

MODULE 5 (Laplace Transforms)

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

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

Text Books

1. H. Anton, I. Biven, S. Davis, "Calculus", Wiley, 10^{th} edition, 2015.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 10^{th} edition, John Wiley& Sons, 2016.

Reference Books

1. J. Stewart, "Essential Calculus", Cengage,2^{nd} edition, 2017.
2. G.B. Thomas and R.L. Finney, "Calculus and Analytic geometry", 9^{th} Edition, Pearson, Reprint,2002.
3. Peter O Neil, "Advanced Engineering Mathematics", 7^{th} Edition, Thomson, 2007.
4. Louis C Barret, C Ray Wylie, "Advanced Engineering Mathematics", Tata McGraw Hill, 6^{th} edition, 2003.
5. Veerarajan T,"Engineering Mathematics for first year", Tata McGraw - Hill, 2008.
6. B.S. Grewal,"Higher Engineering Mathematics", Khanna Publishers, 43 Edition, 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
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
	Total	**45 Hours**

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 $y'' - 2y' + y = e^x cos2x$

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 $1 + \frac{1}{3^2} + \frac{1}{5^2} + \cdots = \frac{\pi^2}{8}$.

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

PART B

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

11. (a) Solve the initial value problem $y'' + 9y = 0, y(0) = 0.2, y'(0) = -1.5$. 7

    (b) By the method of variation of parameters solve $y'' + 4y = tan2x$. 7

OR

12. (a) By the method of undetermined coefficients solve $y'' + 2y' + 4y = 3e^{-x}$. 7

    (b) Solve $x^2y'' + xy' + 9y = 0, y(1) = 0, y'(1) = 2.5$.

    7

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

    (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

OR

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

    (b) Test the convergence of (i)$\sum_{k=1}^{\infty} \frac{k!}{3!(k-1)!3^k}$ (ii) $\sum_{k=1}^{\infty} (\frac{4k-5}{2k+1})^k$ 7

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

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

OR

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

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

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

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

OR

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

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

19. (a) Find the Laplace transform of (i) $tsin2t$ (ii) $e^{-t}sin3tcos2t$ 7

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

OR

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

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

B24PH1T01B	ENGINEERING PHYSICS (B)	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:

CO1	Formulate and solve differential equations for simple, damped, and forced harmonic oscillators to analyze mechanical and physical systems. (Cognitive Knowledge level: Apply)
CO2	Evaluate the static and dynamic characteristics of sensors and explain the working principles of resistive, capacitive, inductive, and Hall effect sensor elements. (Cognitive Knowledge level: Apply)
CO3	Understand the crystalline state of materials, atomic bonding and crystal defects (Cognitive Knowledge level: Understand)
CO4	Apply the principles of acoustics (Sabine's formula) and ultrasonics to assess architectural designs and non-destructive testing (NDT) methodologies, considering their societal and environmental impacts. (Cognitive Knowledge level: Apply)
CO5	Explain the optical processes underlying lasers and optic fibers, and demonstrate their applications in engineering problem-solving and lifelong technological adaptation. (Cognitive Knowledge level: Understand)

Mapping of Course Outcomes With Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	1							1		
CO2	2	1	1	1	1				1		
CO3	2								1		
CO4	2		1	1	1	1			1		
CO5	2			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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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 1 to be answered. Each question carries 14 marks and can have maximum 2 sub divisions.

SYLLABUS

MODULE 1 (7 hours)

Oscillations:

Simple Harmonic Oscillator - differential equation, solution - torsion pendulum Damped harmonic oscillator - differential equation and solution (underdamped case), comparison with undamped harmonic oscillator, logarithmic decrement, relaxation time, Q factor, Forced

Harmonic Oscillator - differential equation and its solution, Analysis of the solution - amplitude resonance

MODULE 2 (8 hours)

Sensors:

Sensors - Introduction and classification, Sensor characteristics (definition only): Static characteristics - transfer function - sensitivity, calibration - calibration error, hysteresis, resolution, output impedance; Dynamic characteristics - zero order, first order and second order sensors (qualitative ideas only)
Sensor elements (principle of working and operation): Resistive elements - Potentiometric measurement of linear and angular displacement, resistive strain gauge; Capacitive elements - capacitive sensor architectures, capacitive displacement and liquid level sensors; Inductive elements - LVDT; Hall effect sensors

MODULE 3 (8 hours)

Bonding in Materials:

Ionic, Covalent, Metallic and Van der Waals bonding; Bonding Energy.Crystalline State - crystal planes and directions - Miller indices, Defects in Crystals - zero, one and two dimensional defects, Grain Boundaries. Movement of atoms - Slip Along Atomic Planes - Dislocation Movement - edge and screw dislocations, Burger vector, Solid state Diffusion - Fick's Laws

MODULE 4 (7 hours)

Acoustics & Ultrasonics:

Acoustics - Characteristics of Sound waves - Pitch, Loudness - Decibel, Absorption coefficient, Reverberation - Reverberation time - Significance, Sabine's formula and applications. Ultrasonics-Production- Magnetostriction effect and Piezoelectric effect, Magnetostriction oscillator and Piezoelectric oscillator – Working, Applications - SONAR, NDT

MODULE 5 (6 hours)

Laser & Fibre Optics:

Optical processes - Absorption, Spontaneous emission and stimulated emission, - Einstein's relations. Principle of laser - conditions for sustained lasing - components of laser - Population inversion - energy source - Pumping, Metastable states - active medium, optical resonator. Construction and working of Ruby laser.
Optic fiber-Principle of propagation of light, Numerical aperture – Derivation Applications of fibers - Intensity modulated sensors.

Text Books

1. Aruldhas G., "Engineering Physics", PHI Pvt. Ltd., 2015
2. M.N. Avadhanulu, P.G. Kshirsagar, TVS Arun Murthy, "A Textbook of Engineering Physics", S.Chand & Co., Revised Edition, 2019.
3. James F. Shackelford, "Introduction to Material Science for Engineers", Pearson, Eighth Edition, 2015.
4. Jacob Fraden, "Handbook of Modern Sensors - Physics, Designs, and Applications", Springer, Fourth Edition, 2010.
5. John P. Bentley, "Principles of Measurement Systems", Pearson Education Limited, Fourth Edition, 2005.

Reference Books

1. Arthur Beiser, "Concepts of Modern Physics ", Tata McGraw Hill Publications, 6th Edition 2003
2. D.K. Bhattacharya, Poonam Tandon, "Engineering Physics", Oxford University Press, 2015
3. Md.N.Khan & S.Panigrahi "Principles of Engineering Physics 1&2", Cambridge University Press, 2016
4. Aruldhas G., "Engineering Physics", PHI Pvt. Ltd., 2015
5. Ajoy Ghatak, "Optics", McGraw Hill Education, Sixth Edition, 2017

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No of Lecture/Tutorial Hours
	Total Hours	36 Hours
	Module 1: Oscillations	7
1.1	Simple Harmonic Oscillator - differential equation, solution - torsion pendulum	3
1.2	Damped harmonic oscillator - differential equation and solution (underdamped case), comparison with undamped harmonic oscillator, logarithmic decrement, relaxation time, Q factor	2

1.3	Forced Harmonic Oscillator - differential equation and its solution, Analysis of the solution - amplitude resonance	2
	Module 2: Sensors	8
2.1	Sensors - Introduction and classification, Sensor characteristics (definition only): Static characteristics - transfer function - sensitivity, calibration - calibration error, hysteresis, resolution, output impedance; Dynamic characteristics - zero order, first order and second order sensors (qualitative ideas only)	2
2.2	Sensor elements (principle of working and operation): Resistive elements - Potentiometric measurement of linear and angular displacement, resistive strain gauge; Capacitive elements - capacitive sensor architectures, capacitive displacement and liquid level sensors; Inductive elements - LVDT; Hall effect sensors	6
	Module 3: Bonding in Materials	8
3.1	Bonding in materials - Ionic, Covalent, Metallic and Van der Waals bonding; Bonding Energy	2
3.2	Crystalline State - crystal planes and directions - Miller indices, Defects in Crystals - zero, one and two dimensional defects, Grain Boundaries	3
3.3	Movement of atoms - Slip Along Atomic Planes - Dislocation Movement - edge and screw dislocations, Burger vector, Solid state Diffusion - Fick's Laws	3
	Module 4: Acoustics & Ultrasonics	7
4.1	Acoustics - Characteristics of Sound waves - Pitch, Loudness - Decibel, Absorption coefficient, Reverberation - Reverberation time - Significance, Sabine's formula and applications	3
4.2	Ultrasonics-Production- Magnetostriction effect and Piezoelectric effect, Magnetostriction oscillator and Piezoelectric oscillator – Working, Applications - SONAR, NDT	4
	Module 5: Laser & Fibre Optics	6
5.1	Optical processes - Absorption, Spontaneous emission and stimulated emission - Einstein's relations	1
5.2	Principle of laser - conditions for sustained lasing - components of laser - Population inversion - energy source - Pumping, Metastable states - active medium, optical resonator	2
5.3	Construction and working of Ruby laser	1
5.4	Optic fibre-Principle of propagation of light, Numerical aperture – Derivation	1
5.5	Applications of fibres - Intensity modulated sensors	1

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1):

1. Define SHM.
2. Define Q factor of a DHO.
3. Explain amplitude resonance.

Course Outcome 2 (CO 2):

1. List the dynamic characteristics of a sensor.
2. Explain the working of a Hall Effect sensor.
3. What is an LVDT?

Course Outcome 3 (CO 3):

1. Differentiate between covalent, metallic and Van der Waal bonding.
2. State Fick's Laws governing solid state diffusion.
3. Describe Edge dislocation.

Course Outcome 4 (CO 4):

1. Write Sabine's formula.
2. What is the change in dB level when the intensity of a source of sound is doubled?
3. Explain two methods of ultrasonic NDT.

Course Outcome 5 (CO 5):

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

MODEL QUESTION PAPER

QP CODE: **Pages: 4**

Reg.No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER B.TECH DEGREE EXAMINATION, JUNE 2024

Course Code: B24PH1T01B

Course Name: ENGINEERING PHYSICS (B)

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Derive the differential equation of a DHO.
2. Define Q factor. What are the factors on which it depends?
3. Differentiate between first order and second order sensors.
4. Explain transfer function, sensitivity and calibration error of a sensor.
5. Explain edge and screw dislocations.
6. State Fick's Laws of solid state diffusion.
7. Differentiate between reverberation and echo.
8. Mention any three applications of ultrasonics.
9. Explain the term population inversion.
10. Describe the principle of operation of optic fibers.

PART B

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

11. (a) Derive the differential equation of an FHO. Obtain the expression for the amplitude of forced oscillations. 10

    (b) The amplitude of an underdamped harmonic oscillation reduces to $\frac{1}{10}^{th}$ of its initial value after 100 oscillations. Its time period is 1.15s. Calculate its relaxation time. 4

OR

12. (a) Frame and solve the differential equation of a DHO and find the solution for the overdamped case. Show graphically the variation of its displacement with time. 10

    (b) DHO of mass 2g has a force constant of 10Nm^{-1} and a damping constant of 2s^{-1}. Find the angular frequency with and without damping. 8

13. (a) Explain any six static characteristics of a sensor. 6

    (b) With the help of a neat diagram, explain the working of a Hall Effect sensor. 8

OR

14. (a) Explain the dynamical characteristics of a sensor. 6

    (b) Explain, with the help of a neat schematic diagram, the working of a resistive strain gauge. 8

15. (a) Explain the terms defects, slip and dislocation movements in crystals. 8

    (b) Explain solid state diffusion. State Fick's Laws. 6

OR

16. (a) Explain the classification of materials based on the bonding. What are the bonding energies in each case? 10

    (b) Calculate the Miller indices of a plane whose intercepts are a, b2 and con the crystallographic axes respectively in a simple cubic cell. 4

17. (a) Derive Sabine's formula and explain its applications. 10

    (b) A hall has a volume of 1000m3 and a total absorption equivalent to 100m2 of OWU. What will be the effect on its reverberation time if the audience fills the hall thereby increasing the absorption by 150m2 of OWU? 4

OR

18. (a) Explain piezoelectric effect and the working of a piezoelectric ultrasonic generator. 10

    (b) A quartz crystal of thickness 1mm vibrates at resonance. Calculate its fundamental frequency if its Young's modulus is $7.96\times10^{9}Nm^{-2}$ and density is 2670 kgm^{-3}. 4

19. (a) Explain the construction and working of Ruby laser. 10

    (b) Describe shortly the main components of a laser system. 4

OR

20. (a) Derive the expression for the Numerical Aperture of an optic fiber. 10

    (b) Calculate the N.A. of an optic fiber having core index of 1.54 and cladding index of 1.5. 4

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

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	2	1	1	1	1	1			1		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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 5 marks

End Semester Examination Pattern

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

SYLLABUS

MODULE 1 (7 hours)

Fundamentals of Nanomaterials

Introduction - Classification - Based on dimension and structural composition - Nanoscale materials – Introduction - Properties and applications of Quantum dots, Graphene and Carbon nanotubes (CNT) – General Properties and applications of nanomaterials - Synthesis of nanomaterials – Top-Down and Bottom-Up approaches – Physical methods of synthesis

- Mechanical milling, Laser ablation and Sputtering - Chemical methods of synthesis – Sol-Gel, co-precipitation and reduction.

MODULE 2 (8 hours)

Spectroscopic and Microscopic Techniques

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

MODULE 3 (7 hours)

Introduction to Electrochemistry and Corrosion Science

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

MODULE 4 (7 hours)

Energy Storage and Harvesting Technologies

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

MODULE 5 (7 hours)

Advanced Materials and Devices for Engineering Applications

Conducting polymers – Introduction - Classification - Intrinsically and extrinsically conducting polymers - Conduction mechanism – Band theory - Polyaniline and polypyrrole - Synthesis, properties and applications – Molecular devices based on conducting polymers – Diodes, Field Effect Transistor and Actuators - Introduction and applications - OLED

– Construction, working and advantages - Smart materials - Thermo and light responsive materials - Introduction and examples - Sensors – Physical, chemical and biosensors – Introduction and applications.

Text Books

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

Reference Books

1. T. Pradeep, "NANO: The Essentials: Understanding Nanoscience and Nanotechnology", McGraw-Hill, 2008.
2. B. Rogers, J. Adams, 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, 7^{th} Edition, 2005.
6. Samuel Glasstone, "An Introduction to Electrochemistry", East-West Press Pvt. Ltd., 2006.
7. Pietro Pedeferri, "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, Charles E. Carraher, "Polymer Chemistry: An Introduction",Marcel Dekker Inc; 4^{th} Revised Edition,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, T. Ikeda, "Smart Light-Responsive Materials", Wiley, 2009.

15. V. Khutoryanskiy, T. Georgiou, "Temperature-Responsive Polymers: Chemistry, Properties and Applications", Wiley, 2018.

16. P. W. Atkins, "Physical Chemistry", Oxford University Press, 10^{th} edn., 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 ATHANASIUS 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

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

OR

12. (a) What are nanoscale materials? Give the properties and applications of quantum dots and graphene. 9

(b) Explain the sputtering method for the synthesis of nanomaterials. 5

13. (a) Explain the principle, instrumentation and working of SEM. 8

(b) Calculate the force constant of HCl molecule, if it shows IR absorption at 2138 cm^{-1}. Given that atomic masses of hydrogen and chlorine are 1 u and 35 u respectively. 6

OR

14. (a) Illustrate the vibrational modes of CO_2 and H_2O. Justify its IR activity. 9

(b) Explain the various energy levels associated with a molecule. 5

15. (a) How electroless plating of copper is carried out? Give the procedure and reactions. 8

(b) Write the cell reactions and calculate the emf of the cell Cu/Cu^{2+} (1M) // Ag^{+} (0.01M) // Ag at 30^{o}C. Given E^{0} $Cu^{2+}/Cu = 0.34$ V and E^{0} $Ag^{+}/Ag = 0.8V$. 6

OR

16. (a) What is cathodic protection? Explain two methods. 9

(b) Write the Nernst equation for Daniel cell and explain the effect of temperature on emf. 5

17. (a) Discuss the construction, working and advantages of Li-ion battery. 9

(b) What is electrolysis of water? 5

OR

18. (a) With a neat diagram explain the construction and working of Hydrogen-Oxygen fuel cell. 8

(b) Explain the classification of supercapacitors. 6

19. (a) Discuss the construction and working of OLED with a diagram. 9

(b) Explain the synthesis, properties and applications of polyaniline. 5

OR

20. (a) Elaborate the classification and applications of conducting polymers. 8

(b) What are smart materials? Give examples for heat responsive materials. 6

B24ES1T08	FUNDAMENTALS OF ELECTRONICS ENGINEERING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course is designed to give an overview of the evolution of electronics and to explain the working principles and examples of essential electronic devices and circuits. It also aims to introduce students to the basics of signal processing and provide an introduction to digital electronics.

Prerequisites

Nil

Course Outcomes

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

CO 1	Identify the active and passive electronic components and their specifications. (Cognitive Knowledge Level-Remember).
CO 2	Understand the working principle of semiconductor devices and Analyze different types of rectifier circuits (Cognitive Knowledge Level-Apply).
CO 3	Comprehend the structure and operation of bipolar junction transistors and Explain the working principle of amplifiers (Cognitive Knowledge Level-Understand).
CO 4	Identify and describe the basic functions and types of operational amplifiers filters, and signal converters (Cognitive Knowledge Level-Apply).
CO 5	Demonstrate proficiency in electronic instrumentation and digital electronics (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
CO 2	3	2	2	2							1
CO 3	3	2	2	2							1
CO 4	3	2	2	2							1
CO 5	3	2	2	2							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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which the student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1 (7 hours)

Introduction to Electronics Components :
Passive components: Resistors - Types of resistors - Fixed Resistors - Variable resistors, resistor tolerance, colour coding, power rating of resistors.
Capacitors: Types of capacitors: Fixed capacitors, Mica, Paper, Ceramic and Electrolytic capacitors, Variable capacitors, voltage rating of capacitors.
Inductors: Fixed and Variable inductors. Transformers, and Electro-mechanical components.

MODULE 2 (8 hours)

Introduction to Semiconductor devices and circuits:
Working of PN Junction diode: Structure and Principle of Operation, V-I Characteristics, Diode Current Equation
Rectifiers: Half wave, full wave, Bridge circuits,
DC Power supply: Block diagram, Capacitor filter, simple Zener regulator.

MODULE 3 (8 hours)

Basics of Semiconductor Devices and Circuits :
Bipolar junction Transistor: NPN, PNP Structure, Principle of operation of NPN transistor
Transistor circuits: Common Emitter Configuration Characteristics
Basic principle of N channel FET and Enhancement MOSFET
Amplifiers, common emitter RC coupled amplifier, Frequency response, Bandwidth.

Analogue Integrated Circuits: Operational amplifier, inverting and non-inverting amplifier (No Analysis required)

MODULE 4 (7hours)

Basics of Signal Processing :
Operational amplifier, inverting and non-inverting amplifier -Open loop and closed loop response (no analysis required)

Filters- Active and passive filters-RC passive filter -Low pass-high Pass-First order active filter- Low pass-high pass (no analysis required)
Concept of ADC- flash type-DAC-Weighted network

MODULE 5 (6 hours)

Basic instrumentation and Digital electronics:
Electronic instrumentation: Transducers: Basic principles of Strain gauge, LVDT, Thermistor, Photodiode, microphones, Loud speaker.
Measurements: Multimeter and X-Y recorder.
Digital electronics: number systems - binary, octal and hexadecimal - conversion - representation of negative numbers using 1's compliment and 2's compliment method. Logic gates – truth table.

Text Books

1. Bell, D. A., Electronic Devices and Circuits, Oxford University Press
2. Chimney Saha, Arindham Halder and Debarati Ganguly, Basic Electronics - Principles and Applications, Cambridge University Press, 2018.
3. S.Sukhija and T.K.Nagsarkar, Basic Electrical and Electronics Engineering, Oxford University Press, 2012.
4. Wayne Tomasi and Neil Storey, A Textbook on Basic Communication and Information Engineering, Pearson, 2010
5. Ramakant A. Gayakwad ,Op-Amps and Linear Integrated Circuits, Pearson Education ,Fourth Edition

Reference Books

1. Boylested, R. L. and Nashelsky, L., Electronic Devices and Circuit Theory, Pearson Education, 2015.
2. Anant Agarwal, Jeffrey Lang, Foundations of Analog and Digital Electronic Circuits, Morgan Kaufmann Publishers, 2005.
3. Bernard Grob, Basic Electronics, McGraw Hil
4. A. Bruce Carlson, Paul B. Crilly, Communication Systems: An Introduction to Signals and Noise in Electrical Communication, Tata McGraw Hill, 5th Edition.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No of Lecture/Tutorial Hours
	Module 1: Introduction to Electronics Components	**7**
1.1	Passive components: Resistors - Types of resistors - Fixed Resistors - Variable resistors, resistor tolerance, color coding, power rating of resistors	3
1.2	Capacitors: Types of capacitors: Fixed capacitors, Mica, Paper, Ceramic and Electrolytic capacitors, Variable capacitors, voltage rating of capacitors.	2
1.3	Inductors: Fixed and Variable inductors. Transformers, and Electro-mechanical components	2
	Module 2:Introduction to Semiconductor devices and circuits	**8**
2.1	Working of PN Junction diode: Structure and Principle of Operation	2
2.2	V-I Characteristics, Diode Current equation	1
2.3	Rectifiers: Half wave, full wave, Bridge circuits,	3
2.4	DC Power supply: Block diagram, Capacitor filter, simple Zener regulator,	2
	Module 3: Basics of Semiconductor Devices and Circuits	**8**
3.1	Bipolar junction Transistor: NPN , PNP Structure, Principle of operation of NPN transistor	2
3.2	Transistor circuits: Common Emitter Configuration Characteristics	1
3.3	Basic principle of N channel FET and Enhancement MOSFET	1
3.4	Amplifiers, common emitter RC coupled amplifier, Frequency response, Bandwidth.	2
3.5	Analogue Integrated Circuits: Operational amplifier, inverting and non-inverting amplifier (No Analysis required)	2
	Module 4: Basics of Analog Circuits and Signal Processing	**7**
4.1	Operational amplifier, inverting and non-inverting amplifier (No Analysis required)-Open loop and closed loop response (no analysis required)	3
4.2	Filters- Active and passive filters-RC passive filter -Low pass-high Pass-First order active filter- Low pass-high pass (no analysis required)	3
4.3	Concept of ADC- flash type-DAC-Weighted network	1
	Module 5: Basic instrumentation and Digital electronics	**6**
5.1	Electronic instrumentation: Transducers: Basic principles of Strain guage, LVDT, Thermistor, Photodiode, microphones, Loud speaker.	2

5.2	Measurements: Multimeter and X-Y recorder.	1
5.3	Digital electronics: number systems - binary, octal and hexadecimal - conversion – representation of negative numbers using 1's compliment and 2's compliment method. Logic gates – truth table.	3
	Total Hours	**36 Hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1):

1. Explain the significance of color coding in identifying the values of resistors.
2. What are the different types of capacitors and Give any two applications of capacitors?
3. Find the capacitance values for the following codes 1) 2n2 2) 104K

Course Outcome 2 (CO 2):

1. Describe the structure of a PN junction diode and its principle of operation
2. What is a regulated power supply? With neat block diagram Summarize the working of DC power supply
3. Narrate the working of capacitor filter.

Course Outcome 3 (CO 3):

1. Compare and contrast the structures of NPN and PNP bipolar junction transistors.
2. What is the need of voltage divider biasing in an RC coupled amplifier?
3. Analyze the importance of selection of operating point in the context of a BJT amplifier.

Course Outcome 4 (CO 4):

1. Describe the key differences between an inverting amplifier and a non-inverting amplifier using operational amplifiers.
2. Compare and contrast active and passive filters, providing examples of each.
3. Discuss the principle of operation of a Digital-to-Analog Converter (DAC) using a weighted network.

Course Outcome 5 (CO 5):

1. Convert 255.5210 to binary and hexadecimal.
2. Implement an AND gate using NOR gate
3. Define logic gates and explain their fundamental role in digital electronics

MODEL QUESTION PAPER

QP CODE: **Pages: 2**

Reg.No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER B TECH DEGREE EXAMINATION, JUNE 2025

Course Code: B24ES1T08

Course Name: FUNDAMENTALS OF ELECTRONICS ENGINEERING

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Identify the color code for the given resistor values
   (a) 1Ω + 5
   (b) 3.3kΩ + 1
   (c) 1 M Ω+ 5
2. Identify the capacitor value with unit.
   (a) 333
   (b) Brown, Black, Red, Brown, Brown
   (c) 103
3. The reverse saturation current of Germanium diode at room temperature is 0.4 micro ampere. Determine the current flowing through the diode when 0.2V is applied at room temperature.
4. Draw the circuit diagram of a full wave bridge rectifier
5. How to calculate the bandwidth of an RC coupled Amplifier?
6. Illustrate the structure of Enhancement MOSFET.
7. Draw the circuit of an inverting amplifier for a gain of 10.
8. Explain the working of an RC high pass filter.

9. Which gates are called universal gates and why?
10. Explain the principle of operation of photo diode

PART B

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

11. Explain the specifications of resistors, capacitors and Inductors

OR

12. With a neat diagram explain the working of electromechanical relay.
13. Explain Half wave rectifier with capacitor filter and draw the output waveforms with high value capacitor and low value capacitors

OR

14. Explain the working of Zener voltage regulator with the help of a neat circuit diagram? What is load regulation and line regulation
15. (a) Discuss in detail the working of a NPN transistor (7)
    (b) Explain the output characteristics of a common emitter configuration (7)

OR

16. Draw the circuit diagram of a typical RC Coupled amplifier with voltage divider bias. Explain the functions of each component.
17. What is the purpose of an Analog-to-Digital Converter (ADC)? Describe and illustrate how a Flash type ADC works.

OR

18. Explain a Digital-to-Analog Converter (DAC). How a DAC using a weighted network operates?
19. Explain the basic principle of LVDT with neat diagram. Give any one application of LVDT.

OR

20. Describe the working of
    (a) Multimeter (7)
    (b) X-Y Recorder (7)

B24ME1T02	STATICS AND DYNAMICS FOR ENGINEERS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course aims to impart the students with a solid comprehension of the fundamental concepts of mechanics. By bridging theory and application, students learn to tackle real-world challenges using reasoned assumptions. Emphasizing problem-solving, the course cultivates and sharpens students' analytical skills. Through theoretical instruction and practical exercises, students gain the ability to analyze and solve engineering problems effectively. Ultimately, the course aims to empower students with the knowledge and skills essential for addressing complex engineering dynamics and statics scenarios with confidence and proficiency.

Prerequisites

NIL

Course Outcomes

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

CO 1	Understand the rigid body mechanics theorems and principles. (Cognitive Knowledge Level: Apply)
CO 2	To apply the conditions of equilibrium to various practical problems involving different force systems. (Cognitive Knowledge Level: Apply)
CO 3	Determine the centroid and moment of inertia of various surfaces and solids. (Cognitive Knowledge Level: Apply)
CO 4	To apply principles of kinematics to bodies in motion. (Cognitive Knowledge Level: Apply)
CO 5	To solve problems involving rigid bodies, applying the properties of distributed areas and Masses. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes With Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	10	10	20
Understand	30	30	40
Apply	60	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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1 (8 hours)

Laws of mechanics- System of forces, System of concurrent forces, Resultant of a force system, Free body diagrams , Principle of transmissibility, Conditions of equilibrium - System of non-concurrent forces, Moment of a force, Varignon's Theorem, Couple, Resultant of non-concurrent forces- Equilibrium of system of forces, Conditions of equilibrium.

MODULE 2 (10 hours)

Analysis of Trusses, Method of joints, Method of sections, Support reactions of beams- Friction, Coulomb's law, Coefficient of friction, Angle of friction, Impending motion of connected bodies- Applications of friction, Screw friction, Belt friction.

MODULE 3 (8 hours)

Centre of Gravity and Centroid- Centroid, Centre of mass, Centre of Gravity, Relationship Between Centre of Gravity, Centre of Mass and Centroid- Moment of inertia, Second moment of area, Radius of gyration- Mass moment of inertia, Parallel axis theorem

MODULE 4 (9 hours)

Kinematics of Rectilinear motion, Displacement, velocity and acceleration, rectilinear motion- Kinematics of Curvilinear motion, Tangential and Normal Components of Acceleration, Radial and Transverse Components of Acceleration.

MODULE 5 (10 hours)

Kinetics of particles, Motion of Bodies in Rectangular Coordinates, Motion of Connected Bodies, D'Alembert's Principle. Planar Kinematics and Kinetics of rigid bodies-Rotation,

Absolute motion, Relative motion, Instantaneous Center of Zero Velocity, Relative Acceleration, Motion relative to rotating axes, Work-energy relations, Impulse and momentum, Impulse-momentum principle. Basics of three-dimensional dynamics of rigid bodies (only theory)

Text Books

1. J.L. Meriam, "Engineering Mechanics: Volume 1: Statics, Volume 2: Dynamics", Wiley.

Reference Books

1. Irving H Shames, "Engineering mechanics: Statics and Dynamics", Pearson Education.
2. Michael E. Plesha, Gary L. Gray, et al, "Engineering mechanics: Statics and Dynamic", McGraw Hill Education.
3. S Timoshenko, D H Young, et al, "Engineering mechanics", McGraw Hill Education.
4. Russell Hibbeler, "Engineering mechanics: Statics and Dynamics", Pearson Education.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No of Lecture/Tutorial Hours
	Module 1:	**8**
1.1	Laws of mechanics-system of forces.	1
1.2	System of concurrent forces: Resultant of a force system, Free body diagrams, Conditions of equilibrium, Principle of transmissibility.	2
1.3	System of non-concurrent forces: Moment of a force.	2
1.4	Varignon's Theorem, Couple.	1
1.5	Resultant of non-concurrent forces, Equilibrium conditions of system of forces.	2
	Module 2:	**10**
2.1	Analysis of Trusses: Method of joints	2
2.2	Method of sections	2
2.3	Support reactions of beams	2
2.4	Friction: Coulomb's law, Coefficient of friction,	1
2.5	Angle of friction, Impending motion of connected bodies.	1
2.6	Applications of friction: Screw friction, Belt friction.	2
	Module 3:	**8**
3.1	Centre of Gravity and Centroid: Centroid, Centre of mass, Centre of Gravity.	2
3.2	Relationship Between Centre of Gravity, Centre of Mass and Centroid.	1
3.3	Moment of inertia: Second moment of area.	2

3.4	Radius of gyration.	1
3.5	Mass moment of inertia, Parallel axis theorem	2
	Module 4	**9**
4.1	Kinematics of Rectilinear motion: Displacement, velocity and acceleration	1
4.2	Rectilinear motion Problems	2
4.3	Kinematics of Curvilinear motion: Tangential and Normal Components of Acceleration	2
4.4	Radial and Transverse Components of Acceleration.	2
4.5	Curvilinear motion problems	2
	Module 5:	**10**
5.1	Kinetics of particles: Motion of Bodies in Rectangular Co-ordinates.	2
5.2	Motion of Connected Bodies, D'Alembert's Principle.	2
5.3	Planar Kinematics and Kinetics of rigid bodies-Rotation, Absolute motion, Relative motion.	1
5.4	Instantaneous Center of Zero Velocity, Relative Acceleration, Motion relative to rotating axes.	2
5.5	Work-energy relations, Impulse and momentum, Impulse-momentum principle.	2
5.6	Basics of three dimensional dynamics of rigid bodies (only theory).	1
	Total Hours	**45 Hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1):

1. State and explain Lami's theorem

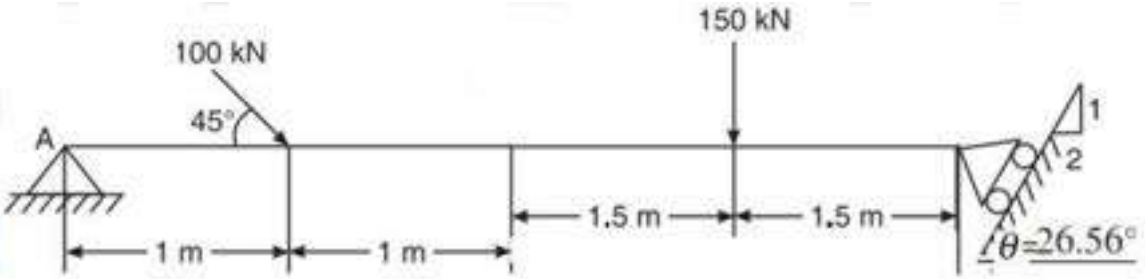
2. What are the conditions of equilibrium in concurrent and non-concurrent force system?

3. State and explain Varignon's theorem for concurrent coplanar forces.

Course Outcome 2 (CO 2):

1. A small block of weight 1000 N as shown in Figure, is placed on a 30° inclined plane with $= 0.25$. Determine the horizontal force to be applied for impending motion down the plane.

2. For the beam with loading shown in Fig, determine the reactions at the supports.

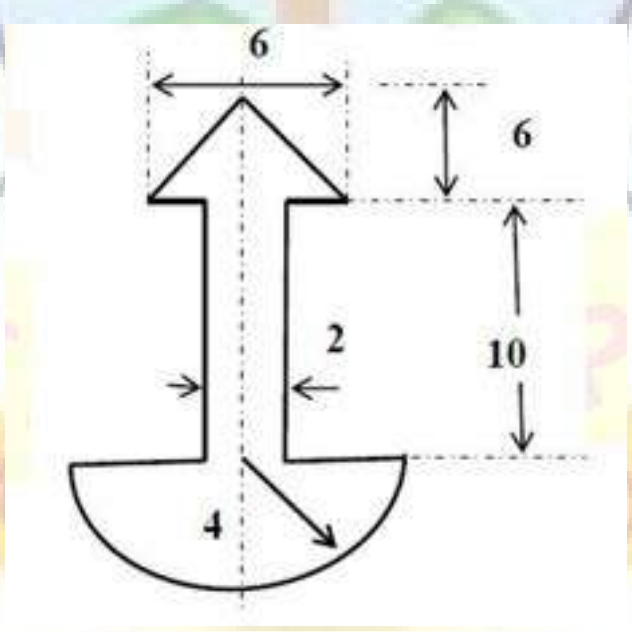


3. A simply supported beam AB of span 4m is carrying point loads 10N, 6N & 4N at 1m, 2m & 3m respectively from support A. Calculate reactions at supports A and B.

Course Outcome 3 (CO 3):

1. Calculate the area moment of inertia of a rectangular cross-section of breadth 'b' and depth 'd' about the centroidal horizontal axis

2. Find the moment of inertia of shaded area about the horizontal and vertical centroidal axis. All dimensions in cm.



3. Write the formula for moment of inertia of a semi-circle about the centroidal axis parallel to the base and hence derive the formula for MI about an axis through its base.

Course Outcome 4 (CO 4):

1. The position of a particle moving along a straight line is defined by the relation . Determine the time taken by the particle when its velocity becomes zero.

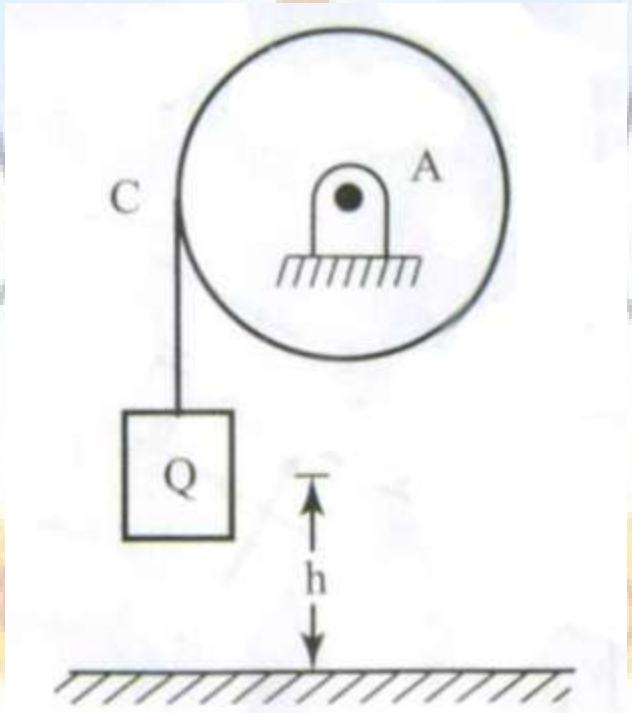
2. A block of mass M1 resting on an inclined plane is connected by a string and pulleys to another block of mass M2 as shown in Fig. Find the tension in the string and acceleration of the blocks. Assume the coefficient of friction between the blocks M1 and the plane to be 0.2. M1 =1500N, M2 = 1000N. Angle of inclined plane = 45^o.

3. A 50 kg mass has a velocity of 10m/s horizontally on a smooth surface. Determine the magnitude of horizontal force required to bring the mass to rest in 5 seconds.

Course Outcome 5 (CO 5):

1. A flywheel weighing 500N and having radius of gyration 0.4 m loses it speed from 300rpm to 180 rpm in 1 minute. Calculate the torque acting on it.

2. A circular disc of radius r=30cm and weight W=145N is free to rotate about its geometric axis. A flexible cord carrying a weight of Q= 45N, is wound around the circumference of the disc as shown in Fig. If the weight Q is released from rest, find (a) the time t required for it to fall through the height h=300cm (b) with what velocity v will it strike the floor?



3. Explain instantaneous centre of zero velocity

MODEL QUESTION PAPER

QP CODE: **Pages: 4**

Reg.No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER B TECH DEGREE EXAMINATION, JUNE 2025

Course Code: B24ME1T02

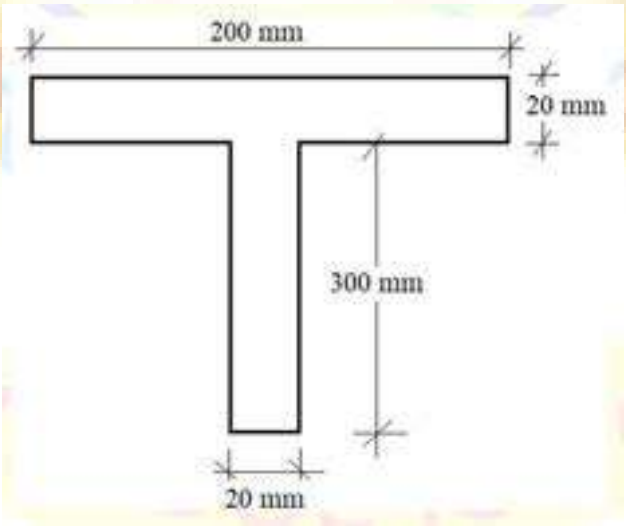
Course Name: STATICS AND DYNAMICS FOR ENGINEERS

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define a couple and explain its characteristics.
2. The resultant of two forces, one of which is double the other, is 490 N. If the direction of the larger force is reversed and the other remains unaltered, the resultant reduces to 100N. Determine the magnitude of the forces and the angle between them.
3. A simply supported beam AB of span 5 m is carrying point loads 5 kN, 3 kN and 2 kN at 1m, 3m and 4m respectively from support A. Calculate the support reaction at B.
4. Distinguish static friction from dynamic friction
5. State and explain parallel axis theorem.
6. Find the centroid of the T section shown



7. The angular acceleration of a particle $= 5t$ rad/s^2. Determine expression for angular velocity w at any instant 't' of the motion, if the particle starts from rest.

8. State D'Alembert's principle

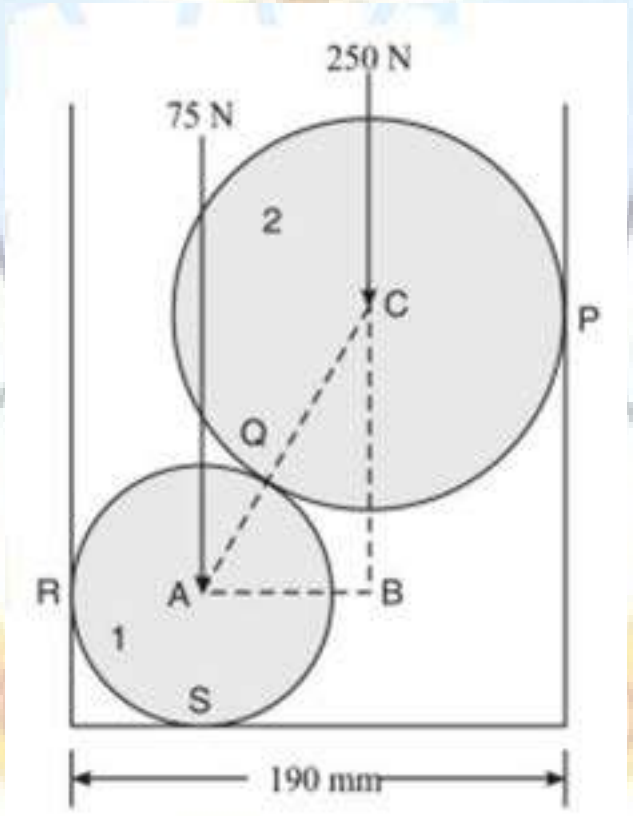
9. While you are riding your bike, you turn a corner following a circular arc. Illustrate the forces that act on your bike to keep you along the circular path

10. Illustrate the significance of instantaneous centre in the analysis of rigid body undergoing rotational motion.

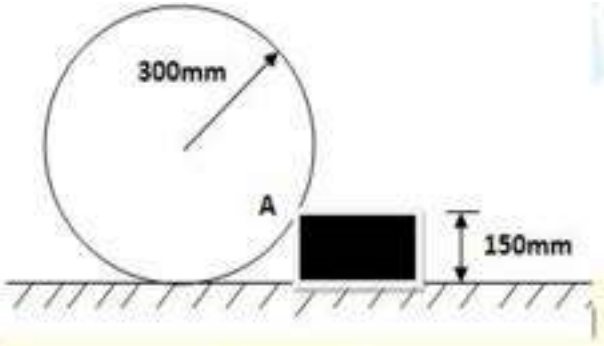
PART B

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

11. Determine the reactions at contact points P, Q, R, and S for the system shown in Figure. The radii of spheres 1 and 2 are, respectively, 40 mm and 60 mm (14 marks)

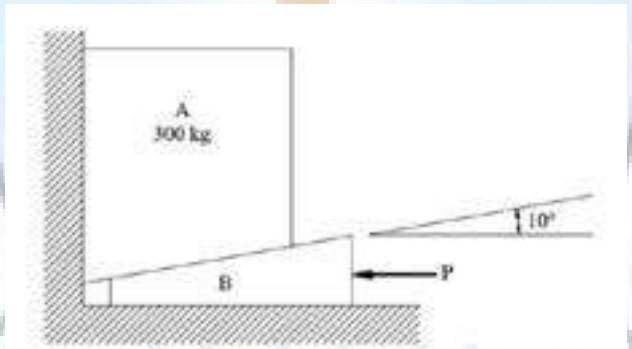


12. A roller of radius 300 mm and weight 1000N is to be pulled over a rectangular block of height 150mm as shown in fig. Determine (i) the horizontal force required to be applied through the centre and (ii) the required horizontal force when it is applied through the top end of vertical diameter. (14 marks)



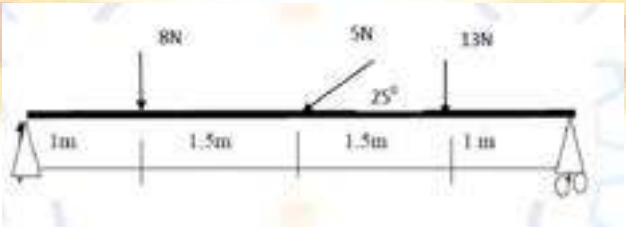
Module 2

13. If the coefficient of static friction equals 0.3 for all surfaces of contact, determine the smallest value of force P necessary to raise the block A of mass 300kg. Neglect the weight of the wedge B. Angle of wedge is 10°. (14 marks)



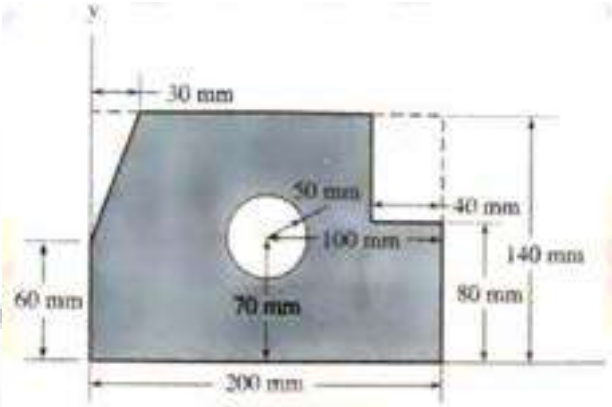
14. (a) What do you understand by the reactions at supports? (4 marks)

    (b) Find the reactions at the supports of the beam given. A is a hinged support and B is a roller support. (10 marks)

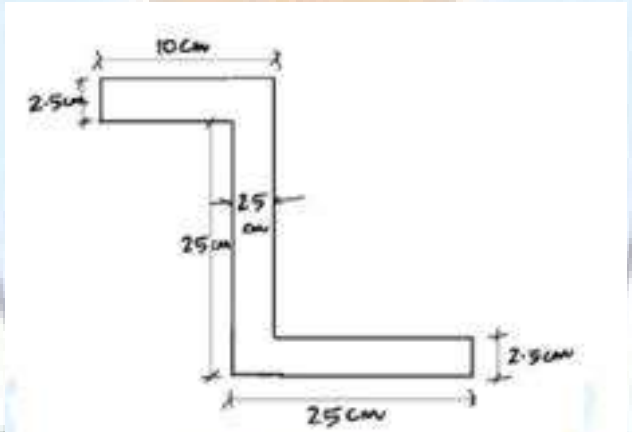


Module – 3

15. Find the centroid of the shaded area shown. (14 marks)

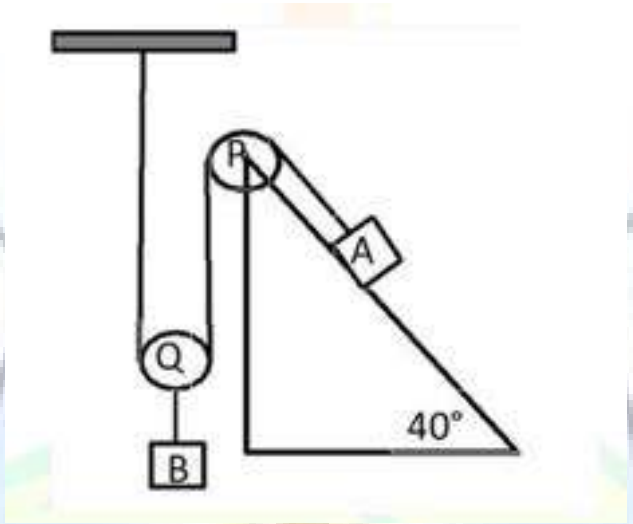


16. Find the centroid of the cross-sectional area of a Z section shown in figure. (14)



Module – 4

17. Determine the tension in the inextensible string and the acceleration of the masses. Consider the pulley as massless and coefficient of friction as 0.20. Block A=200 kg and block B=100kg (14 marks)



18. Two cars A and B travelling in same direction get stopped at a traffic signal. When signal turns green, car A accelerates at 0.75 m/s^2 and 1.75 seconds later, car B starts and accelerates at 1.1 m/s^2. Determine i) when and where B will overtake A and ii) the speed of each car at that time. (14 marks)

Module 5

19. (a) A flywheel rotates with a constant retardation due to breaking, in the first 10 seconds, it made 300 revolutions. At t = 7.5 sec, its angular velocity was 40 rad/s. Determine
    i. The value of constant retardation
    ii. The total time taken to come to rest and
    iii. The total revolutions made till it comes to rest (7marks)

    (b) Two blocks of masses 10 kg and 25 kg are attached to the two ends of a flexible rope. The rope passes over a pulley of diameter 500mm. The mass of the pulley is 7.5 kg and its radius of gyration is 200 mm. Find the acceleration of the masses and the tension on either side of the rope. (7marks)

20. A flywheel is made of steel ring 30mm thick 300 mm wide plate with mean diameter of 1.5m. If initially the flywheel is rotating at 250 rpm, find the time taken by the wheel in coming to rest due to frictional couple of 150 Nm. Take mass density of steel as 7900 kg/m^3. Neglect the effect of spokes. (14 marks)

B24ES1L05	ELECTRICAL AND ELECTRONICS WORKSHOP	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	2	1	1	2024

Preamble

This course is designed to equip students with the foundational knowledge and practical skills necessary to navigate the intricate world of electrical and electronics engineering. It aims to impart the fundamentals of electrical wiring, safety measures, and troubleshooting to students, and exposes them to the concepts of DC and AC electrical machines, allowing them to analyze their performances. The course also provides a basic introduction to electronic hardware systems and offers hands-on training in familiarization, identification, testing, assembling, dismantling, fabrication, and repairing such systems using various tools and instruments available in the electronics workshop.

Prerequisite

Nil

Course Outcomes

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

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

Mapping of Course Outcomes With Program Outcomes

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

Mark Distribution

Total Marks	**CIE Marks**	**ESE Marks**	**ESE Duration**
100	70	30	1 hour

Continuous Internal Evaluation Pattern

Attendance	20 marks
Class Work/ Assessment /Viva-Voce	50 marks
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 Electrical workshop and the Electronics workshop, each in the form of a one-hour written / objective exam. The total marks for this course will be equally divided between the Electrical and Electronics workshops.

SYLLABUS

LIST OF EXPERIMENTS
PART I

ELECTRICAL

1	(a) Familiarization with electrical symbols, measuring instruments, lighting and wiring accessories, tools, and various wiring systems. (b) To familiarize earthing in electrical installations, precautions against electric shock phenomenon and safety procedures.
2	Realization of domestic wiring (a) Wiring of one lamp controlled by two switches (Staircase wiring). (b) Wiring of three lamps controlled by three switches (Godown wiring).
3	(a) Study of fuse, MCB, ELCB, RCCB and selection of fuse rating for circuits with medium and high power. (b) Wiring of the distribution board, including the power plug, an isolator, MCB, and ELCB for 1000 W power.
4	Load test on DC shunt motor and to plot the performance characteristics.
5	(a) Load test on single-phase induction motor and to plot performance characteristics. (b) Load test on single-phase transformer and to plot performance characteristics.
6	Load test on a three-phase squirrel cage induction motor and to plot performance characteristics.
7	Regulation of a three-phase alternator by direct loading at full load upf.

Reference Books

1. D P Kothari & I J Nagrath, Basic Electrical Engineering, 4^{th} Edition, McGraw-Hill 2019.
2. EW. Golding, Electrical Measurements and Measuring Instruments, 5^{th} ed. Reem Publications, 2011.

3. Suresh Kumar K.S, Electrical Circuit and Networks, Pearson Education, New Delhi, 2009.

4. D P Kothari and I J Nagrath, Electric machines, 5^{th} edition ,2017.

5. V K Mehta, Basic Electrical Engineering, Revised edition, S. Chand & Company, New Delhi, 2012

6. J B Gupta, A course in electrical installation estimating and costing, 9^{th} edition, 2012

7. H Cotton, Advanced Electrical Technology, Reem Publications, 2011.

8. Bimbra P. S., Electrical Machinery, 7/e, Khanna Publishers, 2011.

PART II
ELECTRONICS

1	Familiarization/Identification of electronic components with specification (Functionality, type, size, colour coding, package, symbol, cost etc. [Active, Passive, Electrical, Electronic, Electro-mechanical, Wires, Cables, Connectors, Fuses, Relays, Crystals, Displays, Heat sink etc.) .
2	Drawing of electronic circuit diagrams using BIS/IEEE symbols and introduction to EDA tools (such as Dia ,XCircuit, LT SPICE).
3	Familiarization/Application of testing instruments and commonly used tools. [Multimeter, Function generator, Power supply, DSO etc.] [Soldering iron, Desoldering pump, Pliers, Cutters, Wire strippers, Screw drivers, Tweezers etc.
4	Testing of electronic components [Resistor, Capacitor, Diode, Transistor and JFET using multimeter.
5	Inter-connection methods using Bread board and soldering practice. [Soldering - types - selection of materials and safety precautions, soldering practice in connectors and general purpose PCB] .
6	Design and fabrication of a single sided PCB for a simple circuit with manual etching (Ferric chloride) and drilling.

7	Assembling of electronic circuit/system on general purpose PCB or breadboard, test and show the functioning (Any Two circuits). (a) Fixed voltage power supply with transformer, rectifier diode, capacitor filter, Zener/IC regulator. (b) Astable Multivibrator using Transistor (c) Sine wave generation using IC 741 OP-AMP in IC base. (d) RC coupled amplifier with transistor BC107. .

Reference Books

1. Robert L. Boylestad and Louis Nashelsky, Electronic Devices and Circuit Theory, Pearson Education, 2015.
2. Charles K. Alexander, Matthew N.O. Sadiku, Fundamentals of Electric Circuits, Mc-Graw Hill Education Limited, 2022
3. M.W. Schwartz, The Soldering Handbook
4. Thomas L. Floyd, Electronic Devices Conventional current version, Pearson Education, 2015.

B24ME1L01	COMPUTER AIDED MACHINE DRAWING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	3	3	2024

Preamble

The course in Computer-Aided Machine Drawing aims to familiarize students with industrial drafting practices and instill a comprehensive understanding of production drawings, preparing them for the demands of industry. Additionally, the course introduces Computer-Aided Drafting techniques and 2D Modeling to enhance students' proficiency in modern design methodologies. Through practical application and theoretical instruction, students will develop the skills necessary to produce industry-standard production drawings and navigate the complexities of machine drawing in a digital environment. By the conclusion of the course, students will be equipped with the knowledge and practical experience to excel in the field of computer-aided machine drawing and contribute effectively to the industry.

Prerequisites

Nil

Course Outcomes

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

CO 1	Apply the knowledge of engineering drawings and standards to prepare standard dimensioned drawings of machine parts and other engineering components. (Cognitive Knowledge Level: Apply)
CO 2	Apply limits and tolerances to components and choose appropriate fits for given assemblies, surface roughness required. (Cognitive Knowledge Level: Apply)
CO 3	Draw the machine elements detachable joints. (Cognitive Knowledge Level: Understand)
CO 4	Draw the machine elements permanent joints. (Cognitive Knowledge Level: Understand)
CO 5	Prepare part and assembly drawings and Bill of Materials of machine components and valves using CAD software. (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				3		1
CO 2	3	3	2		1				2		1
CO 3	2	2	3		2				2		1
CO 4	2	2	3		2				2		1
CO 5	2	2	3		3			1	2	1	2

Assessment Pattern

Bloom's Category	**Continuous Assessment**	**End Semester Examination (% Marks)**
	Test 1 (%Marks)	
Remember	10	10
Understand	40	30
Apply	50	60
Analyse		
Evaluate		
Create		

Mark Distribution

Total Marks	**CIE Marks**	**ESE Marks**	**ESE Duration**
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern

Attendance	10 marks
Classwork /Assesment viva voce	50 marks
Assignment/Quiz/Course Project	10 marks
Self Study (Quiz/ Seminar/ Microproject/ Analytical Assignments)	5 marks

End Semester Examination Pattern

ESE will be of 2.5-hour duration and will be for 75 marks. The question paper contains two parts. In part A, the first question is compulsory and will be based on modules 1 & 2, carrying 10 marks. The second and third questions will carry 15 marks (the student need to answer only one of these) and will be from module 3 and 4 respectively. Part A should be answered in the A4 size answer booklet provided.

Part B Consists of one question from module 5 (compulsory) which carries 50 Marks. The drafting/drawing of the Part B question should be made in a suitable CAD software.

SYLLABUS

Module 1 (3 hours)
Principles of drawing:
Importance of machine Drawing. BIS code of practice for Engineering Drawing, Lines, types of lines, dimensioning, scales of drawing, sectional views.

Module 2 (6 hours)
Fits and Tolerances: Limits, fits, and tolerances of size and form; Types and grade, use of tolerance tables and specification of tolerances, form and cumulative tolerances, tolerance dimensioning, general tolerances.
Surface Roughness: Preparation of production drawings and reading of part and assembly drawings, surface roughness, indication of surface roughness, etc. Surface quality symbols, terminology and representation on drawings.

Module 3 (6 hours)
Detachable Fasteners:
Screw threads, approximate and conventional representations; Specifications.
Threaded fasteners: Types, forms, standard, and specifications;
Drawing of temporary connections;
Foundation bolts; Locking Devices: Classification, principles of operation, standard types and their proportions.

Module 4 (6 hours)
Permanent Fastenings:
Rivets: Standard forms and proportions; Riveted Joints: Common types of joints, terminology, proportions and representation.
Welds: Types of welds and welded joints, edge preparation, specifications, and representation of welds on drawings.

Module 5 (15 hours)
Introduction to drafting software Auto CAD: Basic commands, keyboard shortcuts. Coordinate and unit setting, Drawing, Editing, Measuring, Dimensioning, Plotting Commands, Layering Concepts, Matching, Detailing, Detailed drawings.
Assembly drawings (2D) with Bill of materials: Drawing of Shaft couplings and Oldhams couplings , Lathe Tailstock and Universal joint , Connecting rod and Plummer block , Rams Bottom Safety Valve, steam stop valve.

Reference Books

1. N. D. Bhatt, *Machine Drawing*, Charotar Publishing House Pvt Ltd, 2016.
2. N. Sidheswar, P. Kanniah and V.V.S. Sastry, *Machine Drawing*, Tata McGraw Hill, 2001
3. SP 46: 1988 *Engineering Drawing Practice for School & Colleges*. Bureau of Indian Standards
4. K. R. Gopalakrishna, *Machine Drawing*, 9th Ed., Subhas Stores, Bangalore, 2005.
5. P I Varghese and K C John, *Machine Drawing*, VIP Publishers.

COURSE CONTENTS AND LAB SCHEDULE

No	Topic	No of Lecture/Tutorial Hours
	Module 1	**3**
1.1	Importance of machine Drawing	1
1.2	BIS code of practice for Engineering Drawing, Lines, types of lines, dimensioning	1
1.3	Scales of drawing, sectional views	1
	Module 2	**6**
2.1	Limits, fits, and tolerances of size and form	1
2.2	Types and grade, use of tolerance tables and specification of tolerances, form and cumulative tolerances	2
2.3	Tolerance dimensioning, general tolerances	1
2.4	Preparation of production drawings and reading of part and assembly drawings	1
2.5	Surface roughness, indication of surface roughness, etc. Surface quality symbols, terminology and representation on drawings	1
	Module 3	**6**
3.1	Screw threads, approximate and conventional representations; Specifications, Threaded fasteners: Types, forms, standard, and specifications	3
3.2	Drawing of temporary connections, Foundation bolts; Locking Devices: Classification, principles of operation, standard types and their proportions	3
	Module 4	**6**
4.1	Rivets: Standard forms and proportions, Riveted Joints: Common types of joints, terminology, proportions and representation	3

4.2	Welds: Types of welds and welded joints, Edge preparation, specifications, and representation of welds on drawings	3
	Module 5	**15**
5.1	Introduction to drafting software Auto CAD, basic commands, keyboard shortcuts. Coordinate and unit setting, Drawing, Editing, Measuring, Dimensioning, Plotting Commands, Layering Concepts, Matching, Detailing, Detailed drawings.	3
5.2	Assembly drawings (2D) with Bill of materials: Drawing of Shaft couplings and OldhamS coupling	3
5.3	MAssembly drawings (2D) with Bill of materials: Lathe Tailstock, Universal joint	3
5.4	Assembly drawings (2D) with Bill of materials: Connecting rod , Plummer block	3
5.5	Assembly drawings (2D) with Bill of materials: Rams Bottom Safety Valve, steam stop valve	3
	Total Hours	**36 Hours**

MODEL QUESTION PAPER

QP CODE: **Pages: 3**

Reg.No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER B TECH DEGREE EXAMINATION, JUNE 2025

Course Code: B24ME1L01

Course Name: COMPUTER AIDED MACHINE DRAWING

Max. Marks: 75 Duration: 2.5 hours

All dimensions in mm. If required, assume missing data appropriately

PART A (SKETCHING) – 25 Marks

(To be answered in A4 sheet)

Question No. 1 is compulsory. From questions 2 and 3 you may answer any one question.

1. Explain surface texture nomenclature with a neat sketch (10 marks)
2. Draw three views of a hexagonal nut having size M30. (15 marks)

or

3. Draw a top half sectional elevation of a Socket and spigot joint which is suitable for shaft having diameter 24 mm. (15 marks)

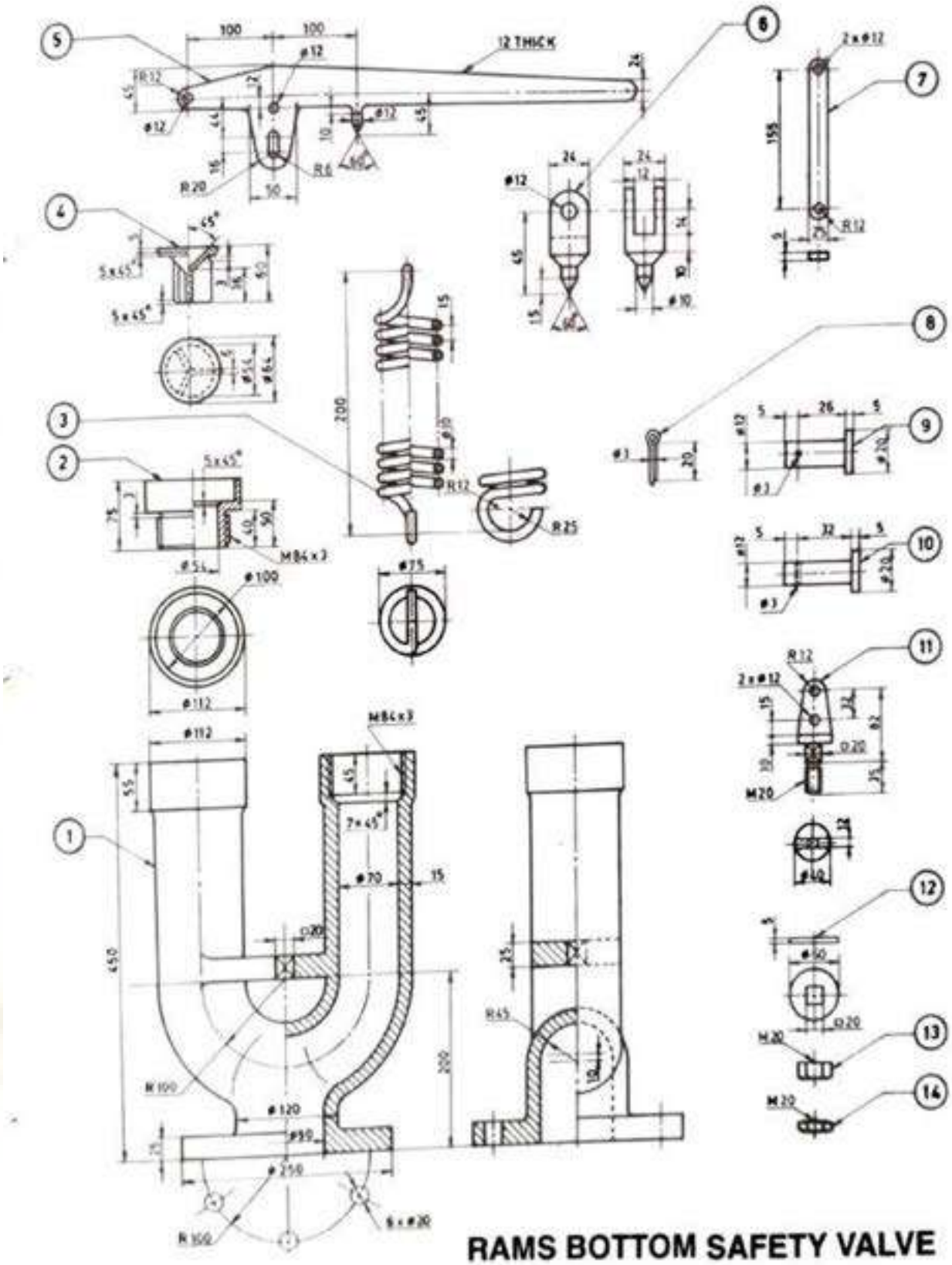
PART B (CAD DRAWING) - 50 Marks

To be drawn/ drafted using any CAD software

4. Draw the assembled view of Rams bottom safety valve as per the given data using any suitable CAD software.

ITEM LIST

Item	Description	Qty.	Material
1	Body	1	C.I.
2	Valve seat	2	G.M.
3	Spring	1	Steel
4	Valve	2	G.M.
5	Lever	1	M.S.
6	Pivot	1	M.S.
7	Link	2	M.S.
8	Split pin	3	M.S.
9	Pin for link	2	M.S.
10	Pin for pivot	1	M.S.
11	Shackle	1	M.S.
12	Washer	1	M.S.
13	Nut	1	M.S.
14	Lock nut	1	M.S.


12 THICK
RAMS BOTTOM SAFETY VALVE

B24PC1L01C	PHYSICS (B) AND CHEMISTRY (A) LAB	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

CO1	Develop analytical / experimental skills and impart prerequisite hands-on experience for engineering laboratories. (Cognitive Knowledge level: Apply)
CO2	Understand the need for precise measurement practices for data recording. (Cognitive Knowledge level: Understand)
CO3	Understand the principle, concept, working and applications of relevant technologies and compare results with theoretical calculations. (Cognitive Knowledge level: Understand)
CO4	Understand and practice fundamental techniques in chemistry to generate experimental skills. (Cognitive Knowledge level: Understand)
CO5	Learn to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments. (Cognitive Knowledge level: Apply)
CO6	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
CO1	2			1	1						
CO2	1			1	1						
CO3	2	1									
CO4	1	1		1	1						
CO5	1	1		3	1						
CO6	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 Physics Lab and Chemistry Lab, each in the form of a 30 minutes written objective examination. The total marks for this course will be equally divided between the Physics and Chemistry Lab.

SYLLABUS

PART I
PHYSICS LAB (B)

LIST OF EXPERIMENTS

1	DSO - Measurement of Frequency and Amplitude.
2	LCR Circuit – Calculation of Q Factor.
3	Measurement of strain using strain gauge and wheatstone bridge.
4	Ultrasonic Diffractometer - measurement of wavelength.

5	Optic Fiber - Measurement of Numerical Aperture.
6	Melde's String - Measurement of Linear Density.
7	Deflection magnetometer-Moment of a magnet- tan A position.
8	Optic Fiber - Measurement of Bending Loss.

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.

PART II
CHEMISTRY LAB (A)

SYLLABUS

LIST OF EXPERIMENTS
(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. G. Svehla, B. Sivasankar, "Vogel's Qualitative Inorganic Analysis", Pearson, 2012.
2. R. K. Mohapatra, "Engineering Chemistry with Laboratory Experiments", PHI Learning, 2017.
3. Muhammed Arif, "Engineering Chemistry Lab Manual", Owl publishers, 2019.
4. Roy K. Varghese, "Engineering Chemistry Laboratory Manual", Crown plus Publishers, 2019.
5. Soney C. George, Rino Laly Jose, "Lab Manual of Engineering Chemistry", S. Chand & Company Pvt Ltd., New Delhi, 2019.
6. S. M. Ashraf, "A Laboratory Manual of Polymers" I. K. International Publishing House Pvt. Ltd., 2008
7. Ulrich Schubert, Nicola Hüsing, "Material Synthesis: A Practical Guide", Springer Vienna, 2008.
8. Anu Tresa Sunny, Prajitha Velayudhan, Sabu Thomas, "Colloidal metal Oxide Nanoparticles: Synthesis, Characterization and Applications", Elsevier Science, 2019.

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

Preamble

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

Prerequisite

Nil

Course Outcomes

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

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

Mapping of Course Outcomes With Program Outcomes

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

Assessment Pattern

Bloom's Category	**Continuous Assessment**	**End Semester Examination (% 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- G D Vs D ebate-Dynamics o f P rofessional P resentation (Individual and Group)- Format of Report, Proposal and Minutes.
Activity- Public Speaking, Podcast preparation, Resume preparation, Video profile creation, Company profiling, G roup d iscussion, T echnical P roposal, S tructured F low A nalysis 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 - S enses 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, C onflicts of In terest, an d Oc cupational Cr ime - Ri ghts and Responsibilities in Engineering - Global Ethical Issues: Multinational Corporations, Environmental Ethics, Business Ethics, and Computer Ethics - Engineers as Leaders, Expert Witnesses, and Contributors to Technological Development.

Text Books

1. Ashraf Rizvi, "Effective Technical Communication", 2^{nd} Edition, McGraw Hill Education, 2017.

2. Meenakshi Raman and Sangeetha Sharma, "Technical Communication: Principles and Practice", 2^{nd} Edition, Oxford University Press, 2011

3. M Govindarajan, S Natarajan and V S Senthil Kumar, Engineering Ethics, PHI Learning Private Ltd, New Delhi,2012.

4. R S Naagarazan, A text book on professional ethics and human values, New age international (P) limited, New Delhi,2006.

Reference Books

1. English for Engineers and Technologists (Combined edition, Vol. 1 and 2), Orient Blackswan 2010.

2. Training in Interpersonal Skills: Tips for Managing People at Work, Pearson Education, India, 6^{th} edition, 2015.

3. Mike W Martin and Roland Schinzinger, Ethics in Engineering,4^{th} edition, Tata McGraw Hill Publishing Company Pvt Ltd, New Delhi,2014.

4. Charles D Fleddermann, Engineering Ethics, Pearson Education/ Prentice Hall of India, New Jersey,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 ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER B.TECH DEGREE EXAMINATION, JUNE 2025

Course Code: B24MC1T03

Course Name: PROFESSIONAL COMMUNICATION AND ETHICS

Max. Marks: 50 Duration:2 hours

PART A

Answer all questions. Each question carries 5 marks.

1. Find out which pair of words 'can be filled-up in the blanks in the sentence in the same sequence to make the sentence grammatically correct and meaningfully complete.

   (a) He was ..... not to ..... done the exercise himself.
   a) expected, be b) required, being c) needed, get d) supposed, have

   (b) A committee has been……to……the transformation of the city into an international finance center.
   a) Constituted, convert b) appointed, oversee c) inducted, change d) converged, evaluate

2. Highlight the differences between a group discussion (GD) and a debate.

3. Briefly explain morals, values, and ethics.

4. Provide an explanation on conflicts of interest with an example.

PART B

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

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

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

OR

6. (a) Compare and contrast the formats of a proposal and a report (7)

   (b) Discuss the challenges and benefits of delivering a presentation in a group setting (8)

7. (a) Exemplify a comprehensive review of integrity and respect for others. (8)

   (b) Explain how caring and sharing differ or exhibit similarities. (7)

OR

8. (a) Explain in detail about professional rights and employee rights. (8)

   (b) Explain the necessity of code of conduct for digital ethics. (7)

B24MC1L02	IDEA LAB	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	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 Micro controller Programming.(Cognitive Knowledge Level : Apply)
CO 4	Build a product for some applications using design and fabrication technologies.(Cognitive Knowledge Level : Create)
CO 5	Create electronic documentation for the system/project using appropriate tools .(Cognitive Knowledge Level : Apply)

Mapping of Course Outcomes With Program Outcomes

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

MAR ATHANASIUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution
Kothamangalam, Kerala, India

B.TECH MECHANICAL 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	B24ME2T01	MECHANICS OF SOLIDS	3-1-0-5	4	4
C	B24ME2T02	MECHANICS OF FLUIDS	3-1-0-5	4	4
D	B24ME2T03	METALLURGY AND MATERIALS SCIENCE	2-1-0-4	3	3
E	B24HU2T02	ENTREPRENEURSHIP AND MANAGEMENT SKILLS FOR ENGINEERS	2-1-0-4	3	3
G	B24ME2L02	MATERIAL TESTING LAB	0-0-3-2	3	2
H	B24ME2L03	MACHINE TOOLS LAB	0-0-3-2	3	2
I	B24MC2T04	UNIVERSAL HUMAN VALUE AND CONSTITUTIONAL RIGHTS	2-0-0-2	2	P/F
J	B24MC2T05	ENERGY CONSERVATION AND ENVIRONMENTAL SUSTAINABILITY	2-0-0-2	2	P/F
M	B24MEM3x	MINOR	3-1-0-5	4	4
			TOTAL	**32**	**22**

MINOR COURSES

BASKET	COURSE NO.	COURSES
BASKET I (DESIGN)	B24MEM31	MECHANICS OF MATERIALS
BASKET II (THERMAL)	B24MEM32	FLUID MECHANICS & MACHINERY
BASKET III (PRODUCTION)	B24MEM33	MATERIAL SCIENCE & TECHNOLOGY

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**.**

Prerequisite:

A basic course in partial differentiation and complex numbers.

Course Outcomes:

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

CO1	Solve Nonlinear and linear partial differential equations (Cognitive Knowledge Level: Apply)
CO2	Solve one dimensional wave equation and heat equation using partial differential equations (Cognitive Knowledge Level: Apply)
CO3	Make use of Cauchy-Riemann equations to understand complex functions, its continuity and differentiability (Cognitive Knowledge Level: Apply)
CO4	Evaluate complex integrals using Cauchy's integral theorem and Cauchy's integral formula (Cognitive Knowledge Level: Apply)
CO5	Develop power series expansion for 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
CO1	2	1			1						
CO2	2	1				1					
CO3	2	2				1					1
CO4	2	1									
CO5	2	2		1	1	1	1				1

Assessment Pattern

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

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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 has to be answered. Each question carries 14 mark and can have a maximum of 2 sub-divisions.

KNOWLEDGE IS POWER

SYLLABUS

MODULE 1: Partial Differential Equations (9 hours)

(Text 1-Relevant portions of sections 17.1, 17.2, 17.3, 17.4, 17.5, 17.7, 18.1, 18.2)

Partial differential equations, Formation of partial differential equations by elimination of arbitrary constants and 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: Applications of Partial Differential Equations (9 hours)

(Text 1-Relevant portions of sections 18.3,18.4, 18.5)

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

MODULE 3: Complex Variable – Differentiation (9 hours)

(Text 2 -Relevant portions of sections 13.3,13.4,17.1,17.2)

Complex function, limit, continuity, derivative, analytic functions, Cauchy-Riemann equation 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: Complex Variable – Integration (9 hours)

(Text 2- Relevant topics from sections14.1, 14.2, 14.3, 14.4)

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: Complex Variable – Series representation (9 hours)

(Text 2- Relevant topics from sections 15.4,16.1, 16.2, 16.3)

Taylor's series and Maclaurin series. Laurent's series (without proof), zeros of analytic functions, singularities, poles, removable singularities, essential singularities, Residues.

Text Books

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, $\mathbf{44^{th}}$ edition 2018.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, John Wiley & Sons, 2016.

Reference Books

1. Peter V. O'Neil, Advanced Engineering Mathematics, Cengage, 7th Edition, 2012.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
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 equations, 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
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
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 $w = z^2, w = e^z, w = \frac{1}{z}$.	3
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 and on multiply connected domain (without proof).	2
4.3	Cauchy Integral formula (without proof).	2
4.4	Cauchy Integral formula for derivatives of an analytic function.	1
5	**Complex Variable – Series representation**	**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
	Total	**45 hours**

Course Level Assessment Questions

Course Outcome 1 (CO1):

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).
2. Solve $(y - z)p + (x - y)q = z - x$.
3. Solve $2zx - px^2$-2qxy +pq = 0.
4. Solve $\frac{\partial u}{\partial x} = 4\ \frac{\partial u}{\partial y}$ where u $u(0, y) = 8e^{-3y}$ by the method of separation of variables.

Course Outcome 2 (CO2):

1. A tightly stretched string of length 50cm has its ends fastened at $x = 0$ and $x = 50$ .The midpoint of the string is then taken to height h and then released from rest in that position. Find the initial position of the string.
2. Find the steady state temperature distribution in a rod of length 30cm if the ends are kept at 10^0C and 100^0C.
3. Write all possible solutions of one dimensional heat equation.
4. A string is stretched between the fixed points (0, 0) and (l, 0) and released at rest from the initial deflection given by $f(x) = \begin{cases} \frac{2k}{l}x\ ,\ when\ 0 < x < \frac{l}{2} \\ \frac{2k}{l}(l - x), when\ \frac{l}{2} < x < l \end{cases}$
5. A rod of length l with insulated sides is initially at a uniform temperature u_0.Its ends are suddenly cooled to 0^0C and are kept at that temperature. Find the temperature function $u(x, t)$.

Course Outcome 3(CO3):

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}(xcos 2y – ysin2y).
4. Find the fixed points of $(a + ib)z^2$.
5. Find the image of $1 \le |z| \le 2,\ \frac{\pi}{6} \le \theta \le \frac{\pi}{3}$ under the mapping $w = z^2$.

Course Outcome 4 (CO4):

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$\oint_C \frac{sinz}{z+4iz}\,dz$ where C is $|z|=1$ in counterclockwise direction.
4. 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.
5. Integrate $\oint_C \frac{sinh2z}{\left(z-\frac{1}{2}\right)^4}\,dz$ in in counterclockwise direction around the unit circle.

Course Outcome 5 (CO5):

1. Find the Maclaurin series expansion of $\frac{z+2}{1-z^2}$.
2. Expand $f(z)=\frac{z+1}{z-1}$ as a Taylor series about $z=-1$.
3. Find the Laurent series of $\frac{-2z+3}{z^2-3z+2}$ valid in (i) $1 \le |z| \le 2$ (ii) $|z| \ge 2$.
4. Find all singular points and residue of the function $cosec\ z$.
5. Find the poles and residue of the function $\frac{1}{z^4-1}$.

KNOWLEDGE IS POWER

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

THIRD SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: B24MA2T03A

Course Name: COMPLEX VARIABLES AND APPLICATIONS OF PDE

Max.Marks:100 Duration:3hours

PARTA

Answer all questions. Each question carries 3marks.

1. Find the partial differential equation by eliminating arbitrary functions f and g from $z = f(x) + g(y)$.
2. Solve $\frac{\partial^2 z}{\partial x^2} = xy$.
3. Write the initial conditions and boundary conditions in which a tightly stretched string of length l with fixed end is initially in equilibrium position and is set vibrating by giving each point a velocity $v_0 sin^3\left(\frac{\pi x}{l}\right)$.
4. Find the steady state temperature distribution in a rod of length 25 cm, if the ends of the rod are kept at 20^0C and 70^0C.
5. Test the continuity at $z = 0$ of $f(z) = \begin{cases} \frac{Re(z)}{1-|z|} & , z = 0 \\ 0 \quad , & z \neq 0 \end{cases}$
6. Show that an analytic function with constant real part is constant.
7. Evaluate $\oint_{-\pi i}^{\pi i} \cos z \, dz$.
8. Evaluate $\oint_C \frac{e^z}{z-3} \, dz$,where C is the circle $|z| = 4$.
9. Find the Maclaurin series of $\frac{1}{1+z^2}$.
10. Find the residue at poles for the function $f(z) = \frac{sinhz}{z^4}$.

PART B

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

Module 1

11a. Form the partial differential equations by eliminating the arbitrary functions from $z = y\,f(x) + x\,g(y)$. (7)

b. Solve $(y + zx)p - (x + yz)q = x^2 - y^2$. (7)

OR

12a. Solve $q + xp = p^2$. (7)

b. Using method of separation of variables, solve $x^2 \frac{\partial u}{\partial x} + y^2 \frac{\partial u}{\partial y} = 0$. (7)

Module 2

13a. Solve one dimensional wave equation $\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$ subject to $u(0,t) = 0$, $u(l,t) = 0, u(x,0) = 3\sin(2\pi x), \frac{\partial u}{\partial t}(x,0) = 0$. (7)

b. Solve the one dimensional heat equation $\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial x^2}$ with boundary conditions $u(0,t) = 0^0 C, u(l,t) = 0^0 C$ and the temperature initially is $u(x,0) = x(l - x)$. (7)

OR

14a. A tightly stretched homogeneous string of length l with fixed ends at $x = 0$ and $x = l$ executes transverse vibrations. Motion starts with zero initial velocity by displacing the string into the form $f(x) = k(x^2 - x^3)$. Find the deflection u(x,t) at any time t. (7)

b. A homogeneous rod of heat conducting material of length l has its ends kept at zero temperature and the temperature initially is $u(x,0) = f(x)$. Find the temperature $u(x,t)$ at any time. (7)

Module 3

15a. Check whether $f(z) = iz\bar{z}$ is analytic. (7)

b. Find the image of $x > 1, y > 0$ under the transformation $w = \frac{1}{z}$. (7)

OR

16a. Show that $u = x^3 - 3xy^2 - 5y$ is harmonic. Also find the corresponding harmonic conjugate function. (7)

b. Find the image of $|z| \leq \frac{1}{2}, \frac{-\pi}{8} < Arg z < \frac{\pi}{8}$ under the mapping $w = z^2$. (7)

Module 4

17a. Evaluate $\oint_C \left(z + \frac{1}{z}\right) dz$ where C is the unit circle traversed anti-clockwise. (7)

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)

OR

18a. Evaluate $\int(z^2+3z)dz$ along the circle $|z|=2$ from (2,0) to (0,2) in counter-clockwise direction. (7)

b. Integrate counterclockwise around the unit circle $\oint_C \frac{\sin(2z)}{z^4}\,dz$. (7)

Module 5

19a. Expand $f(z)=\frac{z-1}{z^2}$ as a Taylor series about $z_0=1$. (7)

b. Find the poles and residues of the function $\frac{1}{z^4-1}$. (7)

OR

20a. Determine and classify the singular points for the following functions:

i) $f(z)=\frac{sinz}{(z-\pi)^2}$

ii) $g(z)=(z+i)^2e^{\left(\frac{1}{z+i}\right)}$. (7)

b. Expand $f(z)=\frac{z}{(z+1)(z+2)}$ as a Laurent's series about $z=-2$ in $0<|z+2|<1$. (7)

KNOWLEDGE IS POWER

B24ME2T01	MECHANICS OF SOLIDS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course is designed to provide students with a thorough understanding of stress, strain, and their interrelation, enabling them to analyze and predict the mechanical behavior of materials across various real-world applications. It covers a wide range of topics, including axial loading, bending, torsion, strain energy, buckling, and failure theories—key concepts essential for designing safe and efficient structural components like beams, columns, shafts, and machinery. Through this course, students will gain the skills to comprehend internal forces within structures, predict their responses to different loading conditions, and make informed decisions about material selection, design criteria, and failure prevention. This foundational knowledge is crucial for multiple engineering fields, particularly civil, mechanical, and aerospace engineering, ensuring the safety, reliability, and longevity of engineering systems and structures.

Prerequisite

Nil

Course Outcomes

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

CO 1	Apply stress-strain relationships to determine the strength of materials under structural and thermal loading. (Cognitive Knowledge Level: Apply)
CO 2	Apply tensorial and Mohr's circle approaches to evaluate stresses, strains, and displacements in structural systems. (Cognitive Knowledge Level: Apply)
CO 3	Perform basic design of shafts subjected to torsional loading and apply principles of column stability to assess buckling behavior. (Cognitive Knowledge Level: Apply)
CO 4	Construct shear force and bending moment diagrams for beams under flexural loads and determine deflection of beams. (Cognitive Knowledge Level: Apply)
CO 5	Apply theories of failure in structural design and solve simple problems using energy methods. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	3	3	2	1		1					1
CO 2	3	3	2	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	10	10	10
Understand	30	30	30
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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

KNOWLEDGE IS POWER

SYLLABUS

MODULE 1 (10 hours)

Introduction to mechanics of deformable bodies, method of sections. Concept of stress and strain. Mechanical properties of materials, stress -strain curve for ductile and brittle materials. Hooke's law, constants of elasticity: Young's modulus, Shear modulus, Bulk modulus and Poisson's ratio. Relations between elastic constants. Constitutive relations for linearly elastic and isotropic materials.

Determination of stress and strain in bars of uniform cross sections subjected to axial loading, axial rigidity.

Effects of thermal loading – thermal stress and thermal strain. Thermal stress on a prismatic bar held between fixed supports.

Simulate stress-strain behaviour of ductile and brittle materials using any analysis software.

MODULE 2 (10 hours)

Stress vectors on cartesian coordinate planes, stress tensor. Equality of cross shears. Cauchy's stress formula. Stress invariants, principal stresses and principal planes, maximum shear stress.

Analysis of strain, displacement field, strain tensor, strain compatibility equations.

Plane stress and plane strain conditions, Mohr's circle construction and problems for 2D case. Implement a code to construct Mohr's circle for a given stress state using any programming language.

MODULE 3 (8 hours)

Introduction to torsion of circular shafts, assumptions in theory of pure torsion, derivation of torsional formula. Torsional rigidity and polar section modulus. Strength and rigidity based design of hollow and solid circular shafts.

Introduction to elastic stability and buckling of columns, modes of failure of columns. Euler's buckling theory for long columns, slenderness ratio, Rankine's theory for short columns.

MODULE 4 (9 hours)

Beams- Classification and types of loadings, flexural formula, section modulus, flexural rigidity.

Shear Force and Bending Moment Diagrams. Differential equations between load, shear force and bending moment. Normal and shear stress in beams shear stress distribution for a rectangular section. Plot shear force, bending moment diagram, and identification of the bending stress, shear stress, and deflection distributions using any numerical analysis software/ programming language.

Deflection of beams using Macauley's method, Differential equation for elastic curve.

MODULE 5 (8 hours)

Introduction to Theories of Failure, Rankine's theory for maximum normal stress, Guest's theory for maximum shear stress, Saint-Venant's theory for maximum normal strain, Hencky-von Mises theory for maximum distortion energy, Haigh's theory for maximum strain energy.

Elastic strain energy and Complementary strain energy. Elastic strain energy for axial loading, transverse shear, bending and torsional loads.

Text Books

1. Mechanics of materials in S.I. units, R. C. Hibbeler, Pearson Higher Education 2018
2. Mechanics of Materials, F. Beer, E. R. Johnston, J. T. DeWolf, Tata McGraw Hill, 2020
3. Advanced Mechanics of Solids, L. S. Srinath, TMH
4. Strength of Materials, S.S. Rattan, McGraw Hill Education India, 2016

Reference Books

1. An introduction to the Mechanics of Solids, S. H. Crandal, N. C. Dhal, T. J. Lardner, McGraw Hill, 2008
2. Mechanics of Materials, James M. Gere, Stephen Timoshenko, CBS Publishers & Distributors, New Delhi,2012
3. Engineering Mechanics of Solids, E. P. Popov, Pearson Education, 2015
4. Mechanics of Materials, Pytel A. and Kiusalaas J. Cengage Learning India Private Limited, 2nd Edition, 2015

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module1	**10**
1.1	Introduction to mechanics of deformable bodies, method of sections.	1
1.2	Concept of stress and strain. Mechanical properties of materials, stress -strain curve for ductile and brittle materials. Hooke's law	2
1.3	Constants of elasticity: Young's modulus, Shear modulus, Bulk modulus and Poisson's ratio.	1
1.4	Relations between elastic constants. Constitutive relations for linearly elastic and isotropic materials.	1
1.5	Determination of stress and strain in bars of uniform cross sections subjected to axial loading, axial rigidity	2
1.6	Effects of thermal loading – thermal stress and thermal strain. Thermal stress on a prismatic bar held between fixed supports.	2
1.7	Simulate stress-strain behaviour of ductile and brittle materials using any numerical analysis software.	1
	Module 2	**10**
2.1	Stress vectors on cartesian coordinate planes, stress tensor.	2
2.2	Equality of cross shears. Cauchy's stress formula.	1
2.3	Stress invariants	1
2.4	Principal stresses and principal planes, maximum shear stress.	1
2.5	Analysis of strain and displacement field	1
2.6	Strain tensor, strain compatibility equations. Plane stress and plane strain conditions	1
2.7	Mohr's circle construction and problems for 2D case.	2

2.8	Implement a code to construct Mohr's circle for a given stress state using any programming language	1
	Module 3	**8**
3.1	Introduction to torsion of circular shafts, assumptions in theory of pure torsion, derivation of torsional formula.	1
3.2	Torsional rigidity and polar section modulus.	1
3.3	Strength and rigidity based design of hollow and solid circular shafts.	2
3.4	Introduction to elastic stability and buckling of columns	1
3.5	Modes of failure of columns. Euler's buckling theory for long columns	2
3.6	Slenderness ratio, Rankine's theory for short columns.	1
	Module 4	**9**
4.1	Beams – Classification and types of loadings, flexural formula, section modulus, flexural rigidity	1
4.2	Shear Force and Bending Moment Diagrams.	3
4.3	Differential equations between load, shear force and bending moment. Normal and shear stress in beams shear stress distribution for a rectangular section.	2
4.4	Plot shear force, bending moment diagram, and identification of the bending stress, shear stress, and deflection distributions using any numerical analysis software/ programming language.	1
4.5	Deflection of beams using Macauley's method, Differential equation for elastic curve.	2
	Module 5	**8**
5.1	Introduction to Theories of Failure, Rankine's theory for maximum normal stress	2
5.2	Guest's theory for maximum shear stress, Saint-Venant's theory for maximum normal strain	2
5.3	Hencky-von Mises theory for maximum distortion energy, Haigh's theory for maximum strain energy.	2
5.4	Elastic strain energy and Complementary strain energy. Elastic strain energy for axial loading, transverse shear, bending and torsional loads.	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Write the generalized Hooke's law for stress-strain relations.
2. Estimate the state of strain from a given state of stress.
3. Analyse the strength of a structure subjected to thermal loading.

Course Outcome 2 (CO2):

1. Determine the resultant traction at a point in a plane using the stress tensor.
2. Evaluate the principal stresses, principal strains and their directions from a given state of stress or strain.
3. Write the stress tensor and strain tensor.

Course Outcome 3 (CO3):

1. Design a shaft to transmit power and torque.
2. Compare strength of solid and hollow shafts.
3. Analyze a column for buckling load.

Course Outcome 4 (CO4):

1. Draw the shear force and bending moment diagrams.
2. Determine the bending stress on a beam subjected to pure bending.
3. Determine deflection of beams using Macauley's method.

Course Outcome 5 (CO5):

1. A bolt is subjected to a direct tensile load of 20 kN and a shear load of 15 kN. Suggest suitable size of this bolt according to various theories of elastic failure, if the yield stress in simple tension is 360 MPa. A factor of safety 2 should be used. Assume Poisson's ratio as 0.3.
2. Apply strain energy method to estimate the deformation of a structure.
3. Determine elastic strain energy for various loading conditions.

KNOWLEDGE IS POWER

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

THIRD SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: **B24ME2T01**

Course Name: **MECHANICS OF SOLIDS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

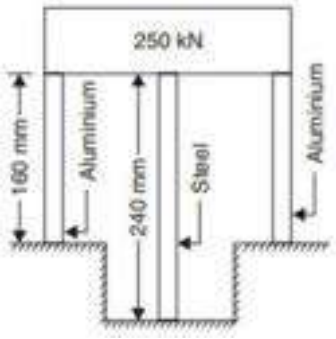
1) Explain Hooke's law for linearly elastic isotropic material.
2) Differentiate between engineering stress strain curve and true stress strain curve.
3) What are stress invariants? Why do they remain invariant?
4) Distinguish between plane stress and plane strain conditions by citing examples for each case.
5) Differentiate between section modulus and polar section modulus.
6) Define slenderness ratio. Explain the limitations of Euler's formula for long columns.
7) Draw the S.F and B.M. diagrams for a simply supported beam of length L carrying a clockwise couple of 'M' Nm at the midsection of the beam.
8) Explain the significance of flexural rigidity and section modulus in the analysis of beams.
9) Explain maximum distortion energy theory.
10) What is elastic strain energy?

PART B

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

Module 1

11) Three pillars, two of aluminium and one of steel support a rigid platform of 250 kN as shown in figure. If the area of each aluminium pillar is 1200 mm^2 and that of steel pillar is 1000 mm^2, find the stresses developed in each pillar. Take $E_s = 2 \times 10^5$ N/mm^2 and $E_a = 1 \times 10^5$ N/mm^2.



(14 marks)

OR

12) A bar of brass 20 mm is enclosed in a steel tube of 40 mm external diameter and 20 mm internal diameter. The bar and the tubes are initially 1.2 m long and are rigidly fastened at both ends using 20 mm diameter pins. If the temperature is raised by 60°C, find the stresses induced in the bar and the tube. Given: $E_s = 2 \times 10^5$ N/mm2, $E_b = 1 \times 10^5$ N/mm2 $\alpha s = 11.6 \times 10^{-6}$/°C and $\alpha b = 18.7 \times 10^{-6}$/°C. (14 marks)

Module 2

13) Determine the stress invariants, principal stresses and principal directions from the stress matrix at a point on a submarine hull given as follows: (14 marks)

$$\begin{bmatrix} 8 & 0 & 6 \\ 0 & 5 & 0 \\ 6 & 0 & -8 \end{bmatrix} \text{MPa}$$

OR

14) At a point in a bracket the stresses on two mutually perpendicular planes are 140 N/mm^2 and 70 N/mm^2 both tensile. The shear stress across these planes is 30 N/mm^2. Using the Mohr's stress circle determine the

i) principal stresses
ii) maximum shear stress
iii) principal planes and
iv) plane of maximum shear stress. (14 marks)

Module – 3

15) a) What are the assumptions taken while deriving Torsion equation (4 marks)

b) A solid aluminum shaft 1.5 m long and 60 mm diameter is to be replaced by a tubular steel shaft of the same length and the same outside diameter such that each of the two shafts could have the same angle of twist per unit torsional moment over the total length. What must the inner diameter of the tubular steel shaft be? Modulus of rigidity of the steel is three times that of aluminium. (10 marks)

OR

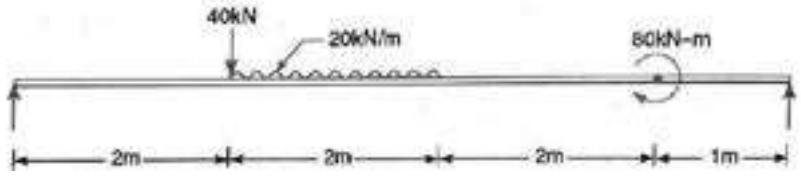
16) A 1.5 m long column has a circular cross section of 5 cm diameter. One of the ends of the column is fixed in direction and position and other end is free. Taking factor of safety as 3, calculate the safe load using

(i) Rankine's formula, take yield stress as 560 N/mm^2 and $\alpha = 1/1600$ for pinned ends and
(ii) Euler's Formula, Take E = 1.2 x10^5 N/mm^2. (14 marks)

Module – 4

17) Draw the shear force and bending moment diagrams for the simply supported beam shown in the figure. Calculate and locate the position of maximum bending moment.

(14 marks)



18) A simply supported beam of 8 m length carries two point loads of 64 kN and 48 kN at 1 m and 4 m, respectively, from the left-hand end. Find the deflection under each load and the maximum deflection using Macauley's method. Take E = 210 GPa and I = 180×10^6 mm^4.

(14 marks)

Module 5

19) Determine the diameter of a bolt which is subjected to an axial pull of 9 kN together with a transverse shear force of 4.5 kN. Using

a. Maximum shear stress theory
b. Maximum strain energy theory
c. Maximum shear strain energy theory

Yield stress corresponding to elastic limit is 225 MPa, Factor of Safety = 3, and Poisson's ratio = 0.3

(14 marks)

OR

20) Derive an expression for the strain energy stored in an element having length L, flexural rigidity EI and Torsional rigidity GJ when subjected to under

a) Bending, M and

b) Torsion, T (14 marks)

KNOWLEDGE IS POWER

B24ME2T02	MECHANICS OF FLUIDS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course is designed to provide a comprehensive understanding of the fundamental properties and behaviors of fluids, which are essential to solving complex problems in engineering and related fields. This course will provide a solid foundation in the application of these concepts to real-world scenarios, particularly focusing on pipe flow systems, boundary layers, and the interaction between fluids and solid surfaces. The course also introduces key techniques such as dimensional analysis, which aids in simplifying complex fluid systems, and model testing, which allows for practical validation of theoretical predictions.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the characteristics of fluids and solve hydrostatic problems. (Cognitive Knowledge Level: Understand)
CO 2	Understand different approaches to fluid kinematics and classify fluid flows. (Cognitive Knowledge Level: Understand)
CO 3	Apply Euler equation and Bernoulli's equation to the fluid flow problems. (Cognitive Knowledge Level: Apply)
CO 4	Apply principles of viscous and turbulent flow to analyze pipe flow behavior, frictional losses, energy transmission, and flow network efficiency. (Cognitive Knowledge Level: Apply)
CO 5	Apply the concept of boundary layer and dimensional analysis for model studies. (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	1					1			1
CO 2	3	2	1	1				1			1
CO 3	3	3	1	2				1			1
CO 4	3	3	2	1				1			1
CO 5	3	2	1	2				1			1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	10	10
Understand	60	30	30
Apply		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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1 (8 hours)

Introduction: Fluids and continuum, Physical properties of fluids, density, specific weight, vapour pressure, Newton's law of viscosity. Ideal and real fluids, Newtonian and non-Newtonian fluids. Fluid Statics- Pressure- density-height relationship, manometers, pressure on plane and curved surfaces, center of pressure, buoyancy, stability of immersed and floating bodies.

MODULE 2 (9 hours)

Kinematics of fluid flow: Eulerian and Lagrangian approaches, classification of fluid flow,1-D, 2-D and 3-D flow, steady, unsteady, uniform, non-uniform, laminar, turbulent, rotational, Irrotational flows, stream lines, path lines, streak lines, stream tubes, velocity and acceleration in fluid, circulation and vorticity, stream function and potential function, Laplace equation, equipotential lines, flow nets, uses and limitations.

MODULE 3 (9 hours)

Control volume analysis of mass, momentum and energy, Equations of fluid dynamics: Differential equations of mass, energy and momentum (Euler's equation), Dynamics of Fluid flow: Bernoulli's equation, Energies in flowing fluid, head, pressure, dynamic, static and total head, Venturi and Orifice meters, Notches and Weirs (description only). Hydraulic coefficients, Velocity measurements: Pitot tube and Pitot- static tube. Modern Flow measurement instruments.

MODULE 4 (9 hours)

Pipe Flow: Viscous flow: Reynolds experiment to classify laminar and turbulent flows, significance of Reynolds number, critical Reynolds number, shear stress and velocity distribution in a pipe, law of fluid friction, head loss due to friction, Hagen-Poiseuille equation. Turbulent flow: Darcy-Weisbach equation, Chezy's equation, Moody's chart, Major and minor energy losses, hydraulic gradient and total energy line, flow through long pipes, pipes in series, pipes in parallel, equivalent pipe, siphon, transmission of power through pipes.

MODULE 5 (10 hours)

Boundary Layer: Growth of boundary layer over a flat plate and definition of boundary layer thickness, displacement thickness, momentum thickness and energy thickness, laminar and turbulent boundary layers, laminar sub layer, velocity profile, separation of boundary and methods of control.

Dimensional Analysis: Dimensional analysis, Buckingham's theorem, important non dimensional numbers and their significance, geometric, Kinematic and dynamic similarity, model studies. Froude, Reynolds, Weber, Cauchy and Mach laws- Applications and limitations of model testing.

Text Books

1. John. M. Cimbala and Yunus A. Cengel, *Fluid Mechanics: Fundamentals and Applications*, McGraw Hill, 4th ed., 2019.

2. Robert W. Fox, Alan T. McDonald, Philip J. Pritchard and John W. Mitchell, *Fluid Mechanics*, Wiley India, 2018.
3. Subramanya K. *Fluid Mechanics and Hydraulic Machines*. McGraw-Hill Education, 2nd ed., 2018.
4. Bansal R. K. *A textbook of Fluid Mechanics and Hydraulic machines*, Laxmi Publications, 9th ed., 2019

Reference Books

1. White, F. M., *Fluid Mechanics*, McGraw Hill Education India Private Limited, 8th ed., 2017
2. Rathakrishnan, E. *Fluid Mechanics*: An Introduction, Prentice Hall India, 3rd ed., 2012.

COURSE CONTENTS AND LECTURE SCHEDULE

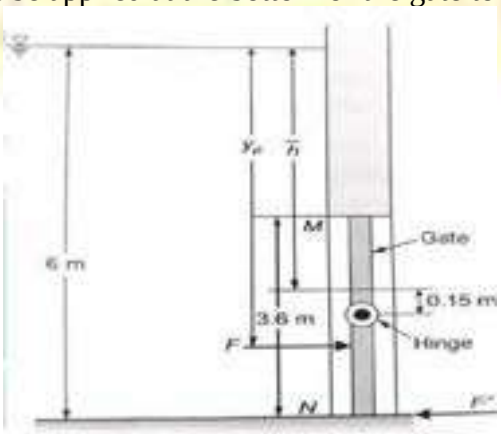
No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**8**
1.1	Introduction: Fluids and continuum, Physical properties of fluids, density, specific weight, vapour pressure.	2
1.2	Newton's law of viscosity. Ideal and real fluids, Newtonian and non-Newtonian fluids.	2
1.3	Fluid Statics- Pressure-density-height relationship, manometers, pressure on plane and curved surfaces.	2
1.4	Center of pressure, buoyancy, stability of immersed and floating bodies.	2
	Module 2	**9**
2.1	Kinematics of fluid flow: Eulerian and Lagrangian approaches.	2
2.2	Classification of fluid flow, 1-D, 2-D and 3-D flow, steady, unsteady, uniform, nonuniform, laminar, turbulent, rotational, irrotational flows.	2
2.3	Stream lines, path lines, streak lines, stream tubes, velocity and acceleration in fluid.	2
2.4	Circulation and vorticity, stream function and potential function.	2
2.5	Laplace equation, equipotential lines, flow nets, uses and limitations.	1
	Module 3	**9**
3.1	Control volume analysis of mass, momentum and energy, Equations of fluid dynamics.	2
3.2	Differential equations of mass, energy and momentum (Euler's equation).	1
3.3	Dynamics of Fluid flow: Bernoulli's equation.	2
3.4	Energies in flowing fluid, head, pressure, dynamic, static and total head, Venturi and Orifice meters.	2
3.5	Notches and Weirs (description only for notches and weirs) Hydraulic coefficients, Velocity measurements: Pitot tube and Pitot-	2

	static tube.	
	Module 4	**9**
4.1	Pipe Flow: Viscous flow: Reynolds experiment to classify laminar and turbulent flows, significance of Reynolds number critical Reynolds number.	2
4.2	Shear stress and velocity distribution in a pipe, law of fluid friction, head loss due to friction, Hagen-Poiseuille equation.	2
4.3	Turbulent flow: Darcy-Weisbach equation, Chezy's equation, Moody's chart.	2
4.4	Major and minor energy losses, hydraulic gradient and total energy line.	2
4.5	Flow through long pipes, pipes in series, pipes in parallel, equivalent pipe, siphon, transmission of power through pipes, efficiency of transmission.	1
	Module 5	**10**
5.1	Boundary Layer: Growth of boundary layer over a flat plate and definition of boundary layer thickness, displacement thickness, momentum thickness and energy thickness.	2
5.2	Laminar and turbulent boundary layers, laminar sub layer, velocity profile.	1
5.3	Von- Karman momentum integral equations for the boundary layers, calculation of drag, separation of boundary and methods of control.	2
5.4	Dimensional Analysis: Dimensional analysis, Buckingham's theorem, important non dimensional numbers and their significance.	2
5.5	Geometric, Kinematic and dynamic similarity, model studies.	2
5.6	Froude, Reynolds, Weber, Cauchy and Mach laws- Applications and limitations of model testing, simple problems only.	1
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. A 3.6 x 1.5 m wide rectangular gate MN is vertical and is hinged at point 0.15 m below the center of gravity of the gate. The total depth of water is 6 m. What horizontal force must be applied at the bottom of the gate to keep the gate closed.



2. A stationary liquid is stratified so that its density is $\rho_0(1+h)$ at a depth h below the free surface. At a depth h in this liquid, what is the pressure in excess of $\rho_0 gh$?
3. If the velocity profile of a fluid is parabolic with free stream velocity 120 cm/s occurring at 20 cm from the plate, calculate the velocity gradients and shear stress at a distance of 0, 10, 20 cm from the plate. Take the viscosity of fluid as 8.5 poise.

Course Outcome 2 (CO2):

1. Differentiate between Eulerian and Lagrangian method of representing fluid motion.
2. A velocity field is given by $u=3y^2$, $v=2x$ and $w = 0$ in arbitrary units. Is this flow steady or unsteady? Is it two or three dimensional?

   At (x, y, z) = (2,1,0), compute

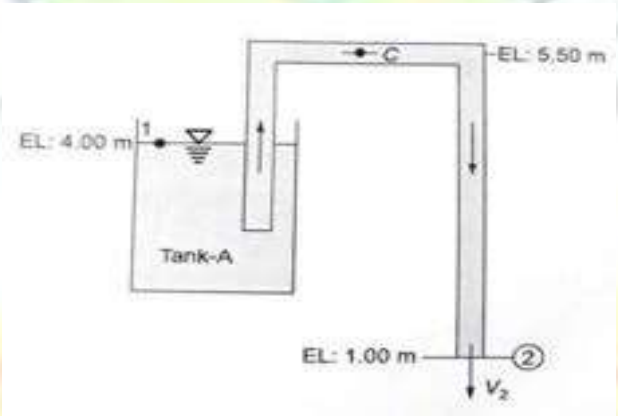
   (a) velocity

   (b) local acceleration

   (c) convective acceleration
3. A stream function in two-dimensional flow is $\Psi = 2xy$. Show that the flow is irrotational and determine the corresponding velocity potential ϕ.

Course Outcome 3 (CO3):

1. A siphon consisting of a pipe of 15 cm diameter is used to empty kerosene oil (relative density=0.8) from tank A. The siphon discharges to the atmosphere at an elevation of 1.00 m. The oil surface in the tank is at an elevation of 4.00 m. The center line of the siphon pipe at its highest point C is at an elevation of 5.50 m.



   Estimate,

   (a) Discharge in the pipe

   (b) Pressure at point C

   The losses in the pipe can be assumed to be 0.5 m up to the summit and 1.2 m from summit to the outlet.
2. Derive the Euler's equation of motion along a streamline and from that derive the Bernoulli's equation.
3. What is Venturi meter? Derive the expression for Coefficient of discharge for Venturi meter

Course Outcome 4 (CO4):

1. Two reservoirs with a difference in water surface elevation of 10 m are connected by a pipeline AB and BC joined in series. Pipe AB is 10 cm in diameter,20 m long and has a value of friction factor, f = 0.02. Pipe BC is 16 cm diameter, 25 m long and has a friction factor f=0.018. The junctions with reservoirs and between pipes are abrupt.
   (a) Sketch Total energy line and Hydraulic gradient line
   (b) Calculate the discharge
2. Oil of viscosity 0.1 Pa.s and specific gravity 0.9 flows through a horizontal pipe of 25mm diameter.
   If the pressure drop per meter length of the pipe is 12 KPa, determine
   (a) Discharge through the pipe
   (b) Shear stress at the pipe wall
   (c) Reynolds number of the flow
   (d) Power required in Watts if the length of the pipe is 50m.
3. In a hydraulic power plant, a reinforced concrete pipe of diameter D is used to transmit water from the reservoir to the turbine. If H is the total head supply at the entrance of the pipe and hf is the loss of head in the pipe, then derive the condition for maximum power supply through the pipe.

Course Outcome 5 (CO5)

1. Write a short note on boundary layer separation and discuss any two methods to control the same.
2. Explain the importance of dimensionless numbers and discuss any two similarity laws. Where are these model laws used?
3. A thin plate is moving in still atmospheric air at a velocity of 4m/s. The length of the plate is 0.5m and width 0.4 m. Calculate the
   (a) thickness of the boundary layer at the end of the plate and
   (b) drag force on one side of the plate.
   Take density of air as 1.25 kg/m^3 and kinematic viscosity 0.15 stokes.

MODEL QUESTION PAPER

QP CODE: Pages: 4

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

THIRD SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: **B24ME2T02**

Course Name: **MECHANICS OF FLUIDS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1		The specific gravity of a liquid is 3.0. What is its specific weight, specific mass, specific volume?
2		State Pascal's law and give some examples where this principle is used.
3		Explain Streamlines, Streak lines and Path lines.
4		What do you understand by the terms: (i) Total acceleration, (ii) Convective acceleration, and (iii) Local acceleration?
5		Name the different forces present in a fluid flow. For the Euler's equation of motion, which forces are taken into consideration.
6		Differentiate between pitot tube and pitot static tube.
7		Define and explain the terms (i) Hydraulic gradient line and (ii) Total energy line.
8		Show that the coefficient of friction for viscous flow through a circular pipe is given by $f = \frac{16}{Re}$ where Re is the Reynolds number.
9		What do you mean by repeating variables? How repeating variables are selected for dimensional analysis.
10		How will you determine whether a boundary layer flow is attached flow, detached flow or on the verge of separation.

PART B

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

Module 1

11	a.	Through a very narrow gap of height h, a thin plate of large extend is pulled at a velocity V. On one side of the plate is oil of viscosity μ_1 and on the other side oil of viscosity μ_2. Calculate the position of the plate so that

a. the shear force on the two sides of the plate is equal.
b. the pull required to drag the plate is minimum.

Assume linear velocity distribution in transverse direction. (7 marks)

b. A metallic cube of 30 cm side and weight 500 N is lowered into a tank containing two fluid layers of water and mercury. Top edge of the cube is at water surface. Determine the position of the block at water mercury interface when it has reached equilibrium. (7 marks)

OR

12 a. A rectangular tank 1.5 m wide, 3 m long and 1.8 m deep contains water to a depth of 1.2 m. Find the horizontal acceleration which may be imparted to the tank in the direction of length so that

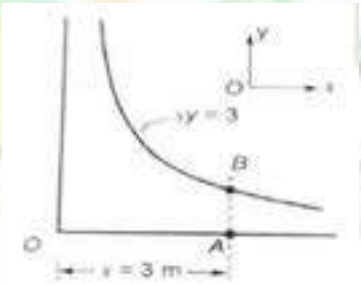
i. there is just no spilling from the tank.
ii. front bottom corner of the tank is just exposed.

(7 marks)

b. A spherical water drop of 1 mm diameter splits up in air into 64 smaller drops of equal size. Find the work required in splitting up the drop. The surface tension coefficient of water in air = 0.073 *N/m* (7 marks)

Module 2

13 If the coefficient of static friction equals 0.3 for all surfaces of contact, determine the smallest value of force P necessary to raise the block A of mass 300kg. Neglect the weight of the wedge B. Angle of wedge is 10°.



Calculate

i. Velocity at B
ii. Convective acceleration at B
iii. Flow per unit width across AB

(14 marks)

OR

14 a. Consider the velocity field given by $u = x^2$ and $v = 2xy$. Find the circulation around the area bounded by A (1,1), B (2,1), C (2,2), D (1,2). (4 marks)

b. Verify whether the following are valid potential functions.

i. $\phi = 2x + 5y$
ii. ii. $\phi = 4x^2 - 5y^2$ (10 marks)

Module 3

15 a. A submarine moves horizontally in sea and has its axis 15 m below the surface of the water. A pitot tube properly placed just in front of the submarine and along its axis is

connected to two limbs of a U tube containing mercury. The difference of level is found to be 170 mm. Find the speed of the submarine knowing that the specific gravity of mercury is 13.6 and that of sea water is 1.026 with respect to water. (7 marks)

b. A pitot tube is inserted in a pipe of 30 cm diameter. The static pressure of the tube is 10 cm of mercury vacuum. The stagnation pressure at the centre of the pipe recorded by the pitot tube is 1.0 N=cm^2. Calculate the rate of flow of water through the pipe, if the mean velocity of flow is 0.85 times central velocity. Assume coefficient of tube as 0.98. (7 marks)

OR

16 a. A smooth pipe of uniform diameter 25 cm, a pressure of 50 KPa was observed at section 1 which has an elevation of 10 m. At another section 2, at an elevation of 12 m, the pressure was 20 KPa and the velocity was 1.25 m/s. Determine the direction of flow and the head loss between the two sections. The fluid in the pipe is water. (7 marks)

b. Petrol of specific gravity 0.8 is following through a pipe of 30 cm diameter. The pipe is inclined at 30° to horizontal. The venturi has a throat diameter of 10 cm. U tube manometer reads 6.25 cm Hg. Calculate the discharge through the pipe. Assume Cd = 0.98. (7 marks)

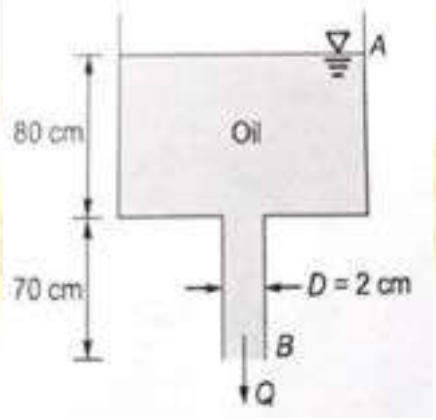
Module 4

17 a. Assuming viscous flow through a circular pipe derive the expression for,

i. Velocity distribution
ii. Shear stress distribution

Also plot the velocity and shear stress distribution. (7 marks)

b. A large tank shown in the figure has a vertical pipe 70 cm long and 2 cm in diameter. The tank contains oil of density 920 Kg/m^3 and viscosity 1.5 poise. Find the discharge through the tube when the height of oil level of the tank is 0.80 m above the pipe inlet. (7 marks)



OR

18 a. A compound piping system consist of 1800 m of 50 cm, 1200 m of 40 cm and 600 m of 30 cm diameter pipes of same material connected in series.

i. What is the equivalent length of a 40 cm pipe of same material?
ii. What is the equivalent diameter of a pipe 3600 m long?
iii. If three pipes are in parallel what is equivalent length of 50 cm pipe?

(10 marks)

b. A pipe line of 2100 m is used for transmitting 103 KW. The pressure at the inlet of the pipe is 392.4N/cm^2. If the efficiency of transmission is 80%, and the diameter of the pipe. Take f = 0.005 (4 marks)

Module 5

19 The pressure difference Δp in a pipe of diameter D and length l due to turbulent flow depends on the velocity V, viscosity μ, density ρ and roughness k. Using Buckingham's π-theorem, obtain an expression for Δp. (14 marks)

OR

20 Derive expressions for the displacement, momentum and energy thickness in connection with the boundary layer theory. (14 marks)

B24ME2T03	METALLURGY & MATERIAL SCIENCE	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course is designed to provide students with a strong understanding of the fundamental principles of mechanics. It explores the relationship between the chemical bonds and crystal structure of metallic materials to their mechanical properties. Students will gain insight into the significance of crystal imperfections, including dislocations, in plastic deformation. The course also covers various phases and heat treatment techniques used to modify the properties of Fe-C alloys. Additionally, students will analyze material failure mechanisms such as fatigue and creep and learn to determine the properties of unknown materials, fostering an awareness of their application in material design.

Prerequisite

Nil

Course Outcomes

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

CO 1	Understand the basic chemical bonds, crystal structures (BCC, FCC, and HCP), and their relationship with the properties. (Cognitive Knowledge Level: Understand)
CO 2	Understand the microstructure of metallic materials using phase diagrams and modify the microstructure and properties using different heat treatments. (Cognitive Knowledge Level: Understand)
CO 3	Quantify mechanical integrity and failure in materials. (Cognitive Knowledge Level: Apply)
CO 4	Apply the basic principles of ferrous and non-ferrous metallurgy for selecting materials for specific applications. (Cognitive Knowledge Level: Apply)
CO 5	Define and differentiate engineering materials on the basis of structure and properties for engineering applications. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	1									1
CO2	3	2	1	1							1
CO3	2	3	1	2							1
CO4	2	2	3			1					1
CO5	2	2	3			1					2

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	10	10
Understand	60	30	30
Apply		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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1 (7 hours)

Atomic structure – Types of bonds: Crystallography: - SC, BCC, FCC, HCP structures, APF - theoretical density (include problems) – Miller Indices: - crystal plane and direction - Modes of plastic deformation: - Slip and twinning -Schmid's law - Crystallization: Effects of grain size, Hall - Petch theory, simple problems.

MODULE 2 (8 hours)

Classification of crystal imperfections - forest of dislocation, role of surface defects on crack initiation- Burgers vector Frank Read source – Correlation of dislocation density with strength and nano concept - high and low angle grain boundaries - driving force for grain growth and applications – Diffusion in solids, Fick's laws, mechanisms, applications of diffusion in mechanical engineering, simple problems.

MODULE 3 (8 hours)

Phase diagrams: - need of alloying - classification of alloys – Hume Rothery`s rule – equilibrium diagram of common types of binary systems: five types - Coring - lever rule and Gibb`s phase rule - Reactions- Detailed discussion on Iron-Carbon equilibrium diagram with microstructure and properties -Heat treatment: - TTT, CCT diagram, applications - Tempering- Hardenability, Jominy end quench test, applications- Surface hardening methods.

MODULE 4 (7 hours)

Strengthening mechanisms - cold and hot working - alloy steels: how alloying elements affecting properties of steel - nickel steels - maraging steel- chromium steels - high speed steels - Cast irons: Classifications; grey, white, malleable and spheroidal graphite cast iron etc, composition, microstructure, properties and applications.

MODULE 5 (6 hours)

Fracture- type of fracture- Ductile Fracture, Brittle Fracture and Fatigue Fracture, DBTT - Definition and Significance, Factors Influencing DBTT, Fatigue: - Creep - Super plasticity - Super alloy- Types of Superalloys (Nickel-based, Cobalt-based, Iron-based), Intermetallic, Titanium - need, properties and applications of composites, Smart Materials-Properties and applications.

Text Books

1. Avner H Sidney, Introduction to Physical Metallurgy, Tata McGraw Hill, 2009.
2. Anderson J.C. et.al., Material Science for Engineers, Chapman and Hall, 1990.

Reference Books

1. William D. Callister Jr. and David G. Rethwisch, Materials Science and Engineering: An Introduction, Wiley 2013.

2. Clark and Varney, Physical metallurgy for Engineers, Van Nostrand, 1964.
3. Dieter George E, Mechanical Metallurgy, Tata McGraw Hill, 1976.
4. Raghavan V, Material Science and Engineering, Prentice Hall, 2004.
5. Reed Hill E. Robert, Physical metallurgy principles, 4th edition, Cengage Learning, 2009.
6. Myers Marc and Krishna Kumar Chawla, Mechanical behavior of materials, Cambridge University press, 2008.
7. Van Vlack -Elements of Material Science - Addison Wesley, 1989.
8. https://nptel.ac.in/courses/113/106/113106032

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module1	**7**
1.1	Atomic structure – Types of bonds: Crystallography: - SC, BCC, FCC, HCP structures	1
1.2	APF - theoretical density (include problems)	2
1.3	Miller Indices: - crystal plane and direction - Modes of plastic deformation	1
1.4	Slip and twinning -Schmid's law - Crystallization	1
1.5	Effects of grain size, Hall - Petch theory, simple problems.	2
	Module 2	**8**
2.1	Classification of crystal imperfections - forest of dislocation, role of surface defects on crack initiation	1
2.2	Burgers vector Frank Read source – Correlation of dislocation density with strength and nano concept	1
2.3	high and low angle grain boundaries - driving force for grain growth and applications	2
2.4	Diffusion in solids, Fick’s laws, mechanisms	2
2.5	Applications of diffusion in mechanical engineering, simple problems.	2
	Module 3	**8**
3.1	Phase diagrams: - need of alloying - classification of alloys	1
3.2	Hume Rothery`s rule – equilibrium diagram of common types of binary systems	1
3.3	Five types - Coring - lever rule and Gibb`s phase rule - Reactions- Detailed discussion on Iron-Carbon equilibrium diagram with microstructure and properties	2
3.4	Heat treatment: - TTT, CCT diagram, applications	2
3.5	Tempering- Hardenability, Jominy end quench test, applications- Surface hardening methods	2
	Module 4	**7**
4.1	Strengthening mechanisms - cold and hot working	1

4.2	Alloy steels: how alloying elements affecting properties of steel	2
4.3	Nickel steels - maraging steel- chromium steels - high speed steels	1
4.4	Cast irons: Classifications; grey, white, malleable and spheroidal graphite cast iron etc	2
4.5	Composition, microstructure, properties and applications	1
	Module 5	**6**
5.1	Fracture- type of fracture, Ductile Fracture, Brittle Fracture and Fatigue Fracture	1
5.2	DBTT Definition and Significance, Factors Influencing DBTT, Fatigue Creep	1
5.3	Super alloy- Types of Superalloys - Intermetallic, Titanium	1
5.4	Need, properties and applications of composites	2
5.5	Smart Materials-Properties and applications.	1
Additional topics: The students may be encouraged to pursue topics related to material science like use of Nano materials to improve the mechanical properties and also on the common materials used in industry.		
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

Understand the basic chemical bonds, crystal structures (BCC, FCC, and HCP), and their relationship with the properties.

1. What are the attributes of atomic and crystalline structures into the stress - strain curve?
2. Explain the significance of long range and short range order of atomic arrangement on mechanical strength.
3. What is the difference between an allotrope and a polymorphism?
4. Draw the (112) and (111) planes in simple cubic cell.

Course Outcome 2 (CO2):

Analyze the microstructure of metallic materials using phase diagrams and modify the microstructure and properties using different heat treatments.

1. What is the driving force for recrystallisation and grain growth of metallic crystals?
2. What is the driving force for the formation of spheroidite.
3. What is tempered martensite?
4. Why 100 % pure metals are weak in strength?

Course Outcome 3 (CO3):

How to quantify mechanical integrity and failure in materials

1. A small hole is drilled through a steel plate ahead of a crack, whether it can stop the crack's progress until repairs can be made. Explain in detail and derive the equation for the principle.
2. Draw and explain S-N curves for ferrous and non-ferrous metals. Explain different methods to improve fatigue resistance.
3. Explain different stages of creep; Give an application of creep phenomenon. What is superplasticity?

Course Outcome 4 (CO4):

Apply the basic principles of ferrous and non-ferrous metallurgy for selecting materials for specific applications.

1. What are the classification, compositions and applications of high speed steel? identify 18:4:1
2. Describe the composition, properties, and use of Bronze and Gun metal.
3. Explain the importance of all the non-ferrous alloys in automotive applications. Elaborate on the composition, properties and typical applications of any five non-ferrous alloys.

Course Outcome 5 (CO5):

Define and differentiate engineering materials on the basis of structure and properties for engineering applications.

1. Carbon is allowed to diffuse through a steel plate 15 mm thick. The concentrations of carbon at the two faces are 0.65 and 0.30kgC/m3Fe, which are maintained constant. If the preexponential and activation energy are 6.2x10-7m2/s and 80,000 J/mol, respectively, compute the temperature at which the diffusion flux is 1.43 x 10-9 kg/m2-s.
2. Explain the fundamental effects of alloying elements in steel on polymorphic transformation temperatures, grain growth, eutectoid point, retardation of the transformation rates, formation and stability of carbides.
3. Describe the kind of fracture which may occur as a result of a loose fitting key on a shaft.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No. : .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

THIRD SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: **B24ME2T03**

Course Name: **METALLURGY & MATERIAL SCIENCE**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What is a slip system? Describe the slip systems in FCC, BCC and HCP metals
2. NASA's Parker Solar Probe will be the first-ever mission to "touch" the Sun. The spacecraft, about the size of a small car, will travel directly into the Sun's atmosphere about 4 million miles from the earth surface. Postulate the coolant used in the parker solar probe with chemical bonds.
3. What is the driving force for grain growth during heat treatment
4. What are the roles of surface imperfections on crack initiation
5. Explain the difference between hardness and hardenability.
6. What is tempered martensite? Explain its structure with sketch.
7. Postulate, why cast irons are brittle?
8. How are properties of aluminum affected by the inclusion of (a) copper and (b) silicon as alloying elements?
9. What is the grain size preferred for creep applications? Why. Explain thermal fatigue?
10. Explain fracture toughness and its attributes into a screw jack?

PART B

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

Module 1

11. a) Calculate the APF of SC, BCC and FCC. (7 marks)

    b) What is slip system and explain why FCC materials exhibit ductility and BCC and HCP exhibit brittle nature with details of slip systems. (7 marks)

OR

12. Explain the effect of: (i) Grain size; (ii) Grain size distribution and (iii) Grain orientation (iv) Grain shape on strength and creep resistance with neat sketches. Attributes of Hall-Petch equation and grain boundaries. (14 marks)

Module 2

13. a) Describe step by step procedure for metallographic specimen preparation? Name different types etchants used for specific metals and methods to determine grain size. (7 marks)

    b) Carbon is allowed to diffuse through a steel plate 15 mm thick. The concentrations of carbon at the two faces are 0.65 and 0.30 kgC/ m^3Fe, which are maintained constant. If the preexponential and activation energy are $6.2x10^{-7}$ m^2 /s and 80,000 J/mol, respectively, compute the temperature at which the diffusion flux is $1.43x10^{-9}$ kg/m^2-s. (7 marks)

OR

14. a**)** Explain the fundamental differences of SEM and TEM with neat sketches. (7 marks)

    b**)** A beam of X-rays wavelength 1.54Å is incident on a crystal at a glancing angle of $8^{o}35^{'}$ when the first order Bragg's reflection occurs calculate the glancing angle for third order reflection. (7 marks)

Module 3

15. Postulate with neat sketches, why 100% pure metals are weaker? What are the primary functions of alloying? Explain the fundamental rules governing the alloying with neat sketches and how is it accomplished in substitution and interstitial solid solutions. (14 marks)

OR

16. Draw the isothermal transformation diagram of eutectoid steel and then sketch and label (1) A time temperature path that will produce 100% pure coarse and fine pearlite (2) A time temperature path that will produce 50% martensite and 50% bainite (3) A time temperature path that will produce 100% martensite (4) A time temperature path that will produce 100% bainite. (14 marks)

Module 4

17. Explain the effect of, polymorphic transformation temperature, formation and stability of carbides, grain growth, displacement of the eutectoid point, retardation of the transformation rates, improvement of corrosion resistance on adding alloy elements to steel. (14 marks)

OR

18. Give the composition, microstructure, properties and applications of (i) Gray iron and SG iron. (ii) White iron and Gray iron. (iii) Malleable iron and Gray iron. (iv) Gray iron and Mottled iron, (v) SG iron and Vermicullar Graphite Iron. (14 marks)

Module 5

19. a) A small hole is drilled through a steel plate ahead of a crack, whether it can stop the crack's progress until repairs can be made or not? Explain in detail and derive the equation. (7 marks)

    b) What is ductile to brittle transition in steel DBTT? What are the factors affecting ductile to brittle transition? Narrate with neat sketch. (7 marks)

OR

20. Classify ceramics with radius ratio with neat sketches. Explain with an example for each of the AX, AmXp, AmBmXp type structures in ceramics with neat sketch. (14 marks).

B24HU2T02	ENTREPRENEURSHIP AND MANAGEMENT SKILLS FOR ENGINEERS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble: In today's rapidly evolving world, engineers must go beyond technical expertise and develop entrepreneurial, managerial, and business acumen to drive innovation and create impact. This course equips students to identify opportunities, develop scalable business models, and apply modern management and marketing strategies. Through activity-based learning, case studies, and real-world problem-solving, students will gain practical insights into leadership, business analysis, and intellectual property rights (IPR), preparing them for startups, corporate leadership, and innovation-driven industries.

Prerequisite

Nil.

Course Outcomes

By the end of this course, students will be able to:

CO 1	Understand key principles and functions of management to grasp modern managerial roles (Cognitive Knowledge Level: Understand)
CO 2	Explain the fundamentals of managing people and processes through effective staffing, motivation, leadership, and control strategies. (Cognitive Knowledge Level: Understand)
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

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	30	30
Understand	60	50	50
Apply		20	20
Analyse			
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1 (6 Hours)

Functions of Management: Introduction to Management: Definitions and scope - Core Functions - Levels of Management - Evolution of Management Thought: Scientific Management (F.W. Taylor), Administrative Management (Henri Fayol), Modern Approaches - Planning and Types of Plans - Organizational Structures: Departmentalization.

MODULE 2 (7 Hours)

Manpower Planning, Leadership & Control:
Staffing - Motivation Theories – Leadership - Understanding Negotiation in Leadership: Types of Negotiation – Barriers to effective communication - Activity-based learning.

MODULE 3 (8 Hours)

Entrepreneurial Thinking & Business Design:
Entrepreneurial Mindset: Growth mindset, risk-taking, and decision-making - Finding a Good Business Idea - How to prepare an Empathy canvas, Value proposition canvas and Idea canvas - Digital Business Models: Freemium, Subscription, Platform-based - Business Model Canvas: Develop and visualise the business model.

MODULE 4 (6 Hours)

Startup Pitching, Marketing & Financials:
Startup Financials: Revenue models, cost structure, funding stages, valuation basics - Investor Pitching: Structure of a pitch deck, communicating value, funding strategy - Digital branding, social media, performance marketing - Growth Strategies: Network effects, influencer marketing, CRM tools.

MODULE 5 (9 Hours)

Intellectual Property Rights (IPR) and Legal Framework
Overview of Intellectual Property Rights (IPR) - Product patents, Process patents- Prerequisites for filing a patent: Novelty, Inventive step, Industrial applicability -Provisional vs Complete application - Common mistakes to avoid before filing - Anatomy of a Patent Document - Overview of databases - Legal Aspects of Startups- Business Registrations and Legal structures – Compliance & Regulatory Requirements.

Reference Books

1. Ricky W. Griffin, Jean M. Phillips & Stanley M. Gully, *Organizational Behavior: Managing People and Organizations*, Cengage Learning, 12th Edition, 2019.
2. Stephen P. Robbins & Timothy A. Judge, *Organizational Behavior*, Pearson Education, 18th Edition, 2019.
3. Heidi M. Neck, Christopher P. Neck & Emma L. Murray, *Entrepreneurship: The Practice and Mindset*, SAGE Publications Inc., 3rd Edition, 2023.
4. Alejandro Cremades, *The Art of Startup Fundraising: Pitching Investors, Negotiating the Deal, and Everything Else Entrepreneurs Need to Know*, Wiley, 2023.
5. Dr R. Radhakrishnan & Dr S. Balasubramanian, *Intellectual Property Rights: Text and Cases*, Excel Books, 2008.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
Module 1 (6 Hours)		
1.1	Introduction to Management: Definitions and scope - Core Functions: Planning, Organizing, Staffing, Directing, Controlling. - Levels of Management: Top, Middle, Lower.	1
1.2	Evolution of Management Thought: Classical approaches -F.W. Taylor, Henri Fayol - Modern Approaches: Systems approach, Contingency approach.	1
1.3	Planning: Importance and steps in planning (objectives, alternatives, evaluation, selection). Types of plans: Strategic, Tactical, Operational, Contingency.	2
1.4	Organizational Structure, Types of Organizational Structures: Functional, Divisional, Matrix, Flat vs. Tall Organizations, Impact of Structure on Business Operations.	2
Module 2 (7 Hours)		
2.1	Manpower Planning, Job Analysis, Recruitment vs Selection - Motivation Theories: Maslow's Hierarchy of Needs, Herzberg's Two-Factor Theory.	2
2.2	Leadership theories: Theory X and Theory Y- Leadership Styles: Autocratic, Democratic, Laissez-faire - Application and effectiveness in various organizational contexts.	2
2.3	Understanding Negotiation in Leadership: Types of Negotiation: Distributive vs. Integrative, Understanding when to compete and when to collaborate. Team building.	2
2.4	Communication Types: Formal and Informal - Barriers to effective communication. Communication distortion. Case studies.	1
Activity-Based Learning: Leadership Roll Playing Simulation: Real-life negotiation scenarios such as investor discussions or conflict resolution between co-founders to practice persuasive communication and strategic thinking.		
Module 3 (8 hours)		
3.1	Entrepreneurial Mindset – Growth mindset, risk-taking, and decision-making.	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.	2
3.4	How Online Businesses Make Money - Freemium Model (Free basic version, pay for extra features) - Subscription Model (Monthly/Yearly payments for continuous use) - Platform Model (Connecting buyers and sellers, like Amazon or Swiggy).	2
Activity: The students may be encouraged to make a Business model plan of their choice.		

Module 4 (6 Hours)		
3.1	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
3.2	Investor Pitching – Structure of a pitch deck, communicating value, and funding strategy.	2
3.3	Modern Marketing – Digital branding, social media, performance marketing - Growth Strategies: Network effects, influencer marketing, CRM tools.	2
Module 5 (9 Hours)		
5.1	Overview of Intellectual Property Rights (IPR) - What is a patent and why does it matter - Types of patentable subject matter: Product Patents, Process Patents- Prerequisites for filing a patent: Novelty, Inventive step, Industrial applicability.	2
5.2	Provisional vs Complete application - When to file a patent (timing strategy for start-ups) - Common mistakes to avoid before filing (e.g., disclosing ideas publicly)	1
5.3	Anatomy of a Patent Document: Title, Abstract, Background, Claims, Drawings - Indian vs International Patents: Filing paths and differences (PCT vs national phase) - Overview of databases: Google Patents, USPTO, WIPO, Espacenet.	2
5.4	Business Registrations & Legal Structures - Types of business entities: Sole Proprietorship, Partnership, LLP, Private Ltd, OPC. Startup India Registration – Benefits & Eligibility.	2
5.5	Compliance & Regulatory Requirements - GST Registration, ROC Filings. Startup Taxation & Incentives. Taxes applicable to startups (Income Tax, GST, TDS, Angel Tax). Tax Benefits for Startups under Section 80-IAC & DPIIT.	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 CO1):

1. Explain the core functions of management and how they support effective organizational operations.
2. How do different levels of management (top, middle, lower) contribute to achieving business goals?
3. Explain the difference between classical and modern approaches to management thought.

Course Outcome 2 (CO2):

1. How do Maslow's Hierarchy of Needs and Herzberg's Two-Factor theory explain employee motivation in the workplace?
2. Enumerate the key differences between Theory X, Theory Y, and Theory Z, and how they influence leadership styles.

3. How do BATNA and ZOPA help leaders make effective negotiation decisions during team conflicts or business deals?

Course Outcome 3 (CO3):

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 (CO4):

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 (CO5):

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 ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

THIRD SEMESTER B. TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: **B24HU2T02**

Course Name: **ENTREPRENEURSHIP AND MANAGEMENT SKILLS FOR ENGINEERS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define the core functions of management with a brief explanation.
2. Differentiate between flat and tall organisational structures.
3. Explain the key difference between Maslow's and Herzberg's motivation theories.
4. Differentiate between distributive and integrative negotiation with one example each.
5. List any three key components of the Business Model Canvas and explain their purpose.
6. Explain the concept of a growth mindset in the context of entrepreneurship.
7. State the meaning of 'burn rate' and why it is important for startups.
8. Mention any two components of a startup pitch deck and explain their importance.
9. State the difference between a provisional and a complete patent application.
10. List any two legal compliance requirements for a startup after registration.

PART B

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

MODULE 1

11a. Illustrate the three levels of management with suitable examples and describe the role of each in organizational decision-making. (7 Marks)

b. Discuss the different types of plans (strategic, tactical, operational, contingency) with examples, and explain how they guide managerial actions. (7 Marks)

OR

12a. Explain the five core functions of management and discuss their importance in running a business efficiently. (7 Marks)

b. Compare the classical management theories of F.W. Taylor and Henri Fayol with modern approaches like systems and contingency theory. (7 Marks)

MODULE 2

13a. Describe Herzberg's Two-Factor Theory and Maslow's Hierarchy of Needs. How can managers apply them to motivate employees? (7 Marks)

b. Explain the steps involved in manpower planning and differentiate between recruitment and selection with examples. (7 Marks)

OR

14a. You are leading a startup team facing internal disagreements. Explain how different types of negotiation and leadership styles can help resolve the conflict. (7 Marks)

b. Discuss the impact of communication barriers on leadership effectiveness and provide examples of how leaders can overcome them. (7 Marks)

MODULE 3

15a. 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

16a. 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)

MODULE 4

17a. 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

18a. 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)

MODULE 5

19a. 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

20a. 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)

B24ME2L02	MATERIAL TESTING LAB	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

This course provides a thorough understanding of materials used in mechanical engineering, emphasizing structure-property relationships and their applications. Through lab experiments, students explore mechanical properties like tensile strength, shear strength, bending, and torsion, while measuring key properties such as Young's Modulus, yield strength, and ultimate tensile strength. They will also learn to calculate stress, strain, and displacement and apply these concepts to real-world structural design and analysis.

Overall, the Strength of Materials Lab develops essential technical skills, promotes safety awareness, ensures measurement accuracy, and encourages critical thinking—preparing students for effective engineering design and analysis.

Prerequisite

Nil

Course Outcomes

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

CO 1	Evaluate the strength of materials subjected to shear and bending forces. (Cognitive Knowledge Level: Apply)
CO 2	Verify the Clerk Maxwell's law of reciprocal and to determine the Young's Modulus of Material. (Cognitive Knowledge Level: Apply)
CO 3	Develop skills in presenting experimental findings with appropriate graphs, tables, and technical reports data in a structured and scientifically acceptable format. (Cognitive Knowledge Level: Analyse)
CO 4	Identify and specify suitable material for applications in the field of design and manufacturing. (Cognitive Knowledge Level: Apply)
CO 5	To evaluate the toughness of the given material using the Izod and Charpy impact testing machines. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Evaluation
- Class work/ Assessment : 10 marks
- Viva (Self Study) : 10 marks

Viva voce / test : 15 marks
Record : 5 marks

End Semester Examination Pattern

Experiment part : 70 marks
Viva voce : 30 marks

Guidelines for award of marks for the experiment part:

Preliminary work : 15 Marks
Implementing the work/Conducting the experiment : 25 Marks
Performance, result and inference : 30 Marks

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SYLLABUS

LIST OF EXPERIMENTS

(Minimum **eight** experiments are mandatory)

1	To conduct tension test on ductile material (mild steel/ tor-steel/ high strength steel) using Universal tension testing machine and Extensometer.
2	To conduct shear test on mild steel rod.
3	To conduct Hardness test of a given material. (Brinell, Vickers and Rockwell)
4	To determine torsional rigidity of mild steel/copper/brass rod.
5	To determine flexural rigidity of mild steel/ copper/brass material using universal testing machine.
6	To conduct a Toughness test of the given material using Izod and Charpy Machine.
7	To determine spring stiffness of close coiled/open coiled/series/parallel arrangements
8	To conduct bending test on wooden beam
9	To conduct strain measurements using strain gauges
10	To conduct an experiment to Verify Clerk Maxwell's law of reciprocal deflection and determine young's Modulus of steel.
Activity: Students may be encouraged to visit different CNC facilities	

Reference Books

1. G E Dieter. Mechanical Metallurgy, McGraw Hill,2013
2. Dally J W, Railey W P, Experimental Stress analysis, McGarw Hill,1991 S Timoshenko, D H Young, et al, "Engineering mechanics", McGraw Hill Education.
3. Timoshenko, S., & Young, D. (2021). Strength of Materials. (3rd edition).
4. Russell Hibbeler, "Engineering mechanics: Statics and Dynamics", Pearson Education.

KNOWLEDGE IS POWER

B24ME2L03	MACHINE TOOLS LAB	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

The Machine Tools Lab provides hands-on exposure to various machine tools and machining processes. It aims to develop proficiency in operating lathe, drilling, milling, grinding and welding equipment while understanding their operational principles. The lab emphasizes analyzing machining parameters like cutting force, power consumption, and surface finish, enhancing skills in manufacturing techniques, and exploring metallurgical processes such as heat treatment and testing. It bridges theoretical knowledge with practical applications, preparing students to tackle real-world machining challenges effectively.

Prerequisite

Nil

Course Outcomes

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

CO 1	Apply knowledge of machine tool operations to produce precision components with the desired quality. (Cognitive Knowledge Level: Apply)
CO 2	Analyze cutting mechanics to evaluate power consumption and optimize machining parameters for various operations. (Cognitive Knowledge Level: Analyze)
CO 3	Develop and select appropriate machining processes and parameters tailored for different materials. (Cognitive Knowledge Level: Analyze)
CO 4	Identify welded joints and inspect their quality for discontinuities and defects using standard evaluation techniques. (Cognitive Knowledge Level: Apply)
CO 5	Identify the effects of heat treatment processes on metallurgical properties and interpret the results for practical applications. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment (%Marks)	End Semester Examination (%Marks)
Remember	10	
Understand	20	20
Apply	40	50
Analyze	30	30
Evaluate		
Create		

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Evaluation
- Class work/ Assessment : 10 marks
- Viva (Self Study) : 10 marks

Viva voce / test : 15 marks
Record : 5 marks

End Semester Examination Pattern

Experiment Part : 70 marks
Viva voce : 30 marks

Guidelines for award of marks for the experiment part:

Preliminary work : 5 Marks
Dimensions and Overall Finish : 60 Marks
Overall Finish : 5 Marks

KNOWLEDGE IS POWER

SYLLABUS

LIST OF EXPERIMENTS

Part A: Machining Experiments (Minimum 8 required)	
1	**Study and exercises on conventional lathe**: Plain turning, step turning, taper turning, ball and curve making, and thread cutting.
2	**Exercises on Engine Lathe**: Measurement of cutting forces using a lathe tool dynamometer.
3	**Exercises on shaping machine**: Flat surfaces, grooves, and keyways.
4	**Exercises on slotting machine**: Flat surfaces, grooves, keyways, curved surfaces, boring, and spur gear making.
5	**Exercises on radial drilling machine**: Drilling, boring, reaming, tapping, and countersinking.
6	**Exercises on radial drilling machine**: Measurement of cutting forces using a drill dynamometer.
7	**Study and exercises on cylindrical grinding machine, surface grinding machine, and universal tool & cutter grinding machine**.
8	**Study and exercises on universal milling machines**: Plane and pocket milling, slab milling, keyways, and spur gear making
9	**Exercises on milling machine**: Measurement of cutting forces in the milling process.
10	**Exercises on normal arc welding, GTAW, and GMAW**: Butt welding and lap welding of mild steel sheets.
11	**Exercises on gas welding**: Butt welding and lap welding of mild steel sheets.
Part B: Advanced Machining and Metallurgy Studies (Minimum 2 required)	
12	**Preparation and microscopic examination of ferrous and non-ferrous material samples**: Specimen preparation, etching, and grain size analysis.
13	**Heat treatment experiments**: Effects of annealing, normalizing, hardening, and tempering on steel. Hardness testing and microstructural analysis under different conditions.
14	**Study and demonstration of modern cutting machines**: Water jet cutting. Abrasive water jet cutting. Laser beam machining.

Reference Books

1. Acherkan N. S., "Machine Tool Vol. I-IV," MIR Publications.
2. HMT, "Production Technology," Tata McGraw Hill Education.
3. W. A. J. Chapman, "Workshop Technology Part I," ELBS & Edward Arnold Publishers.
4. S. K. Hajra Choudhury, A. K. Hajra Choudhury, et al., "Elements of Workshop Technology Vol. I & II," Media Promoters and Publishers Pvt. Ltd.

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.

Prerequisite:

Nil

Course Outcomes:

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

CO1	Understand the importance of value education for holistic development and to fulfill human aspirations. (Cognitive Knowledge Level: Understand)
CO2	Develop more awareness of themselves, and their surroundings (family, society, nature) to build harmonious and respectful relationships. (Cognitive Knowledge Level: Apply)
CO3	Understand and appreciate the preamble and other features in the Indian Constitution to promote responsible citizenship. (Cognitive Knowledge Level: Understand)
CO4	Understand the fundamental rights and duties enshrined in the Indian Constitution and the Directive Principles of State Policy and their role in shaping governance and social welfare. (Cognitive Knowledge Level: Understand)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1						2	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 Tests	End Semester Examination ((%)
	Test ((%))	
Remember	30	30
Understand	60	60
Apply	10	10
Analyze		
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 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.

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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. A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 3rd Revised Edition, Excel Books, New Delhi, 2023.
2. The Teacher's Manual for a Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 3rd Revised Edition, Excel Books, New Delhi, 2023.
3. D D Basu, Introduction to the constitution of India, Lexis Nexis, New Delhi, 26/e, 2022
4. P M Bhakshi, The constitution of India, Universal Law, 19/e, 2023

Reference Books

1. M Govindarajan, S Natarajan and V S Senthil Kumar, Engineering Ethics, PHI Learning Private Ltd, New Delhi,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, The constitution of India, Govt of India, New Delhi,2019.
4. J N Pandey, The constitutional Law of India, Central Law Agency, Allahabad, 51e,2019.
5. M V Pylee, Indias Constitution, S Chand and Company, New Delhi,16e, 2016.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No. of Lecture/ Tutorial hours
	Module 1	**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	**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	**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	**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
	Total	**24 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1)

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 (CO2)

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 (CO3)

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 (CO4)

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.

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MODEL QUESTION PAPER

QP CODE: Pages: 1

Reg. No.: .....

Name: .....

MAR ATHANASIUS 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

PARTA

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.

Module 1

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)

Module 2

7. Distinguish between 'animal consciousness and 'human consciousness' (9 marks)

OR

8. Relationship is – between one Self(I1) and another Self(I2). Examine this statement. (9 marks)

Module 3

9. Summarize the various methods of acquiring Indian citizenship. (10 Marks)

OR

10. Examine the salient features of the Indian constitution. (10 marks)

Module 4

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.

Prerequisite: NIL

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

CO1	Classify various energy resources and describe the importance of energy conservation **(Cognitive Knowledge Level: Understand)**
CO2	Explain the principles of renewable energy systems and their applications **(Cognitive Knowledge Level: Understand)**
CO3	Recognize major environmental impacts due to energy consumption and explain basic pollution control measures. **(Cognitive Knowledge Level: Understand)**
CO4	Describe sustainability concepts and apply simple strategies for environmental protection and green practices in day-to-day engineering tasks **(Cognitive Knowledge Level: Apply)**

Mapping of course outcomes with program outcomes

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

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) : 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 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 the first two modules carries 9 marks and each question of the last two modules carries 10 marks.

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SYLLABUS

Module 1: Energy Resources and Conservation (6 hours)

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: Renewable Energy Technologies (6 hours)

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: Environmental Impact and Pollution Control (6 hours)

Pollution Types and Sources: Air pollution: industrial emissions, vehicular sources - Water pollution: domestic, industrial, agricultural waste - Soil pollution: hazardous waste, agrochemicals, 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: Sustainability and Green Practices (6 hours)

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.

TEXTBOOKS 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 CONTENT AND LECTURE SCHEDULE

No.	Topics	No. of Lecture hours/ tutorial hours
	Module 1	**6 hours**
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 & technological interventions	1
1.3	Energy Policy and Planning: National Energy Policy, Energy Conservation Act, BEE initiatives	1
1.4	Energy Auditing: Preliminary & Detailed audits, Performance Indicators, Case Studies	2
1.5	Energy-efficient Buildings & Smart Cities: Passive design, daylighting, automation	1
	Module 2	**6 hours**
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	**6 hours**
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	**6 hours**
4.1	Sustainable Development: Principles, SDGs, resource efficiency	1
4.2	Green Buildings: Concepts, features, materials, passive design, renewables integration, green certifications	1
4.3	Carbon Credits: Earning, trading, CDM, voluntary carbon markets	1
4.4	Carbon Pricing and Subsidies: Internal pricing, UJALA, PM-KUSUM, FAME	1
4.5	Life Cycle Assessment (LCA): Phases, case studies	1
4.6	Smart Cities and Resilience: Urban planning	1
Students shall present a seminar based on case studies of Life Cycle Assessment (LCA) conducted on a product of their choice.		
	Total	**24 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

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 (CO2):

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 (CO3):

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 (CO4):

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 ATHANASIUS 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 one full question from each module)***

MODULE 1

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)

MODULE 2

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)

MODULE 3

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)

MODULE 4

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)

KNOWLEDGE IS POWER

MAR ATHANASIUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution
Kothamangalam, Kerala, India

B.TECH MECHANICAL ENGINEERING

SEMESTER 3

(MINOR)

SYLLABUS

B24MEM31	MECHANICS OF MATERIALS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

The course aims to equip students with the knowledge of stress, strain, and their relationship, and to enable them to analyze and predict the mechanical behavior of materials in various practical scenarios. The course encompasses a broad spectrum of topics including axial loading, bending, torsion, strain energy, buckling, and failure theories, all of which are essential for the design of safe and efficient structural elements such as beams, columns, shafts, and machinery. By learning this course, students develop the ability to comprehend the internal forces within structures, anticipate their behaviour under different types of loading conditions, and make prudent decisions regarding material selection, design factors, and failure prevention. This course forms the foundation for multiple engineering disciplines, especially civil, mechanical, and aerospace engineering, and is critical for ensuring the safety, reliability, and durability of engineering systems and structures.

Prerequisite

Nil

Course Outcomes

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

CO 1	Identify the strength of materials using stress-strain relationships for structural and thermal loading. (Cognitive Knowledge Level: Apply)
CO 2	Apply tensorial and Mohr's circle approaches to evaluate stresses, strains, and displacements in structural systems. (Cognitive Knowledge Level: Apply)
CO 3	Develop basic design of shafts subjected to torsional loading and analyse stability of columns subjected to buckling. (Cognitive Knowledge Level: Apply)
CO 4	Construct shear force and bending moment diagrams for beams under flexural loads and determine deflection of beams. (Cognitive Knowledge Level: Apply)
CO 5	Apply theories of failure in structural design and solve simple problems using energy methods. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6		PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	3	3	2	1		1						1
CO 2	3	3	2	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	10	10	10
Understand	30	30	30
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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

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SYLLABUS

MODULE 1 (10 hours)

Introduction to mechanics of deformable bodies, method of sections. Concept of stress and strain. Mechanical properties of materials, stress -strain curve for ductile and brittle materials. Hooke's law, constants of elasticity: Young's modulus, Shear modulus, Bulk modulus and Poisson's ratio. Relations between elastic constants. Constitutive relations for linearly elastic and isotropic materials.

Determination of stress and strain in bars of uniform cross sections subjected to axial loading, axial rigidity.

Effects of thermal loading – thermal stress and thermal strain. Thermal stress on a prismatic bar held between fixed supports.

MODULE 2 (10 hours)

Stress vectors on cartesian coordinate planes, stress tensor. Equality of cross shears. Cauchy's stress formula. Stress invariants, principal stresses and principal planes, maximum shear stress.

Analysis of strain, displacement field, strain tensor, strain compatibility equations.

Plane stress and plane strain conditions, Mohr's circle construction and problems for 2D case.

MODULE 3 (8 hours)

Introduction to torsion of circular shafts, assumptions in theory of pure torsion, derivation of torsional formula. Torsional rigidity and polar section modulus. Strength and rigidity based design of hollow and solid circular shafts.

Introduction to elastic stability and buckling of columns, modes of failure of columns. Euler's buckling theory for long columns, slenderness ratio, Rankine's theory for short columns.

MODULE 4 (9 hours)

Beams – Classification and types of loadings, flexural formula, section modulus, flexural rigidity.

Shear Force and Bending Moment Diagrams. Differential equations between load, shear force and bending moment. Normal and shear stress in beams shear stress distribution for a rectangular section.

Deflection of beams using Macauley's method, Differential equation for elastic curve.

MODULE 5 (8 hours)

Introduction to Theories of Failure, Rankine's theory for maximum normal stress, Guest's theory for maximum shear stress, Saint-Venant's theory for maximum normal strain, Hencky-von Mises theory for maximum distortion energy, Haigh's theory for maximum strain energy.

Elastic strain energy and Complementary strain energy. Elastic strain energy for axial loading, transverse shear, bending and torsional loads. Castigliano's second theorem, reciprocal relation, proof for Castigliano's second theorem. Simple problems to find the deflections using Castigliano's theorem.

Text Books

1. Mechanics of materials in S.I.units, R. C. Hibbeler, Pearson Higher Education 2018
2. Mechanics of Materials, F. Beer, E. R. Johnston, J. T. DeWolf, Tata McGraw Hill, 2020
3. Advanced Mechanics of Solids, L. S. Srinath, TMH
4. Strength of Materials, S.S.Rattan , McGraw Hill Education India, 2016

Reference Books

1. An introduction to the Mechanics of Solids, S. H. Crandal, N. C. Dhal, T. J. Lardner, McGraw Hill, 2008
2. Mechanics of Materials, James M. Gere, Stephen Timoshenko, CBS Publishers & Distributors, New Delhi,2012
3. Engineering Mechanics of Solids, E. P. Popov, Pearson Education, 2015
4. Mechanics of Materials, Pytel A. and Kiusalaas J. Cengage Learning India Private Limited, 2nd Edition, 2015

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module1	**10**
1.1	Introduction to mechanics of deformable bodies, method of sections.	2
1.2	Concept of stress and strain. Mechanical properties of materials, stress -strain curve for ductile and brittle materials. Hooke's law	2
1.3	Constants of elasticity: Young's modulus, Shear modulus, Bulk modulus and Poisson's ratio.	1
1.4	Relations between elastic constants. Constitutive relations for linearly elastic and isotropic materials.	1
1.5	Determination of stress and strain in bars of uniform cross sections subjected to axial loading, axial rigidity	2
1.6	Effects of thermal loading – thermal stress and thermal strain. Thermal stress on a prismatic bar held between fixed supports.	2
	Module 2	**10**
2.1	Stress vectors on cartesian coordinate planes, stress tensor.	2
2.2	Equality of cross shears. Cauchy's stress formula.	1
2.3	Stress invariants	1
2.4	Principal stresses and principal planes, maximum shear stress.	1
2.5	Analysis of strain and displacement field	1
2.6	Strain tensor, strain compatibility equations. Plane stress and plane strain conditions	2
2.7	Mohr's circle construction and problems for 2D case.	2

	Module 3	**8**
3.1	Introduction to torsion of circular shafts, assumptions in theory of pure torsion, derivation of torsional formula.	1
3.2	Torsional rigidity and polar section modulus.	1
3.3	Strength and rigidity based design of hollow and solid circular shafts.	2
3.4	Introduction to elastic stability and buckling of columns	1
3.5	Modes of failure of columns. Euler's buckling theory for long columns	2
3.6	Slenderness ratio, Rankine's theory for short columns.	1
	Module 4	**9**
4.1	Beams – Classification and types of loadings, flexural formula, section modulus, flexural rigidity	2
4.2	Shear Force and Bending Moment Diagrams.	3
4.3	Differential equations between load, shear force and bending moment. Normal and shear stress in beams shear stress distribution for a rectangular section.	2
4.4	Deflection of beams using Macauley's method, Differential equation for elastic curve.	2
	Module 5	**8**
5.1	Introduction to Theories of Failure, Rankine's theory for maximum normal stress	1
5.2	Guest's theory for maximum shear stress, Saint-Venant's theory for maximum normal strain	1
5.3	Hencky-von Mises theory for maximum distortion energy, Haigh's theory for maximum strain energy.	1
5.4	Elastic strain energy and Complementary strain energy. Elastic strain energy for axial loading, transverse shear, bending and torsional loads.	2
5.5	Castigliano's second theorem, reciprocal relation	1
5.6	Proof for Castigliano's second theorem. Simple problems to find the deflections using Castigliano's theorem.	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Write the generalized Hooke's law for stress-strain relations.
2. Estimate the state of strain from a given state of stress.
3. Analyse the strength of a structure subjected to thermal loading.

Course Outcome 2 (CO2):

1. Determine the resultant traction at a point in a plane using the stress tensor.
2. Evaluate the principal stresses, principal strains and their directions from a given state of stress or strain.
3. Write the stress tensor and strain tensor.

Course Outcome 3 (CO3):

1. Design a shaft to transmit power and torque.
2. Compare strength of solid and hollow shafts.
3. Analyze a column for buckling load.

Course Outcome 4 (CO4):

1. Draw the shear force and bending moment diagrams.
2. Determine the bending stress on a beam subjected to pure bending.
3. Determine deflection of beams using Macauley's method.

Course Outcome 5 (CO5):

1. A bolt is subjected to a direct tensile load of 20 kN and a shear load of 15 kN. Suggest suitable size of this bolt according to various theories of elastic failure, if the yield stress in simple tension is 360 MPa. A factor of safety 2 should be used. Assume Poisson's ratio as 0.3.
2. Apply strain energy method to estimate the deformation of a structure.
3. Use strain energy method to estimate the loads acting on a structure for a maximum deflection.

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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: **B24MEM31**

Course Name: **MECHANICS OF MATERIALS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1) Explain Hooke's law for linearly elastic isotropic material.
2) Write down the general expression for temperature stress and explain the terms in it.
3) What are stress invariants? Why do they remain invariant?
4) Distinguish between plane stress and plane strain conditions by citing examples for each case.
5) Define Flexural rigidity. What is its importance?
6) Define slenderness ratio. Explain the limitations of Euler's formula for long columns.
7) Draw the S.F and B.M. diagrams for a simply supported beam of length L carrying a clockwise couple of 'M' Nm at the midsection of the beam.
8) Explain the significance of flexural rigidity and section modulus in the analysis of beams.
9) Explain Rankine's theory of failure.
10) Explain Castigliano's second theorem

PART B

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

Module 1

11) A steel rod of 20 mm diameter is enclosed in a copper tube of 40 mm external diameter and 25 mm internal diameter. The tube is closed at each end by rigid plates of negligible thickness. If the assembly is subjected to an axial load of 50 kN, find the stress developed in each material. Take the elastic modulus of copper and steel as 1.2 $x10^5$ N/mm^2 and 2 $x10^5$ N/mm^2. (14 marks)

.

OR

12) A bar of brass 20 mm is enclosed in a steel tube of 40 mm external diameter and 20 mm internal diameter. The bar and the tubes are initially 1.2 m long and are rigidly fastened at both ends using 20 mm diameter pins. If the temperature is raised by 60°C, find the stresses induced in the bar and the tube. Given: $E_s = 2 \times 10^5$ N/mm^2, $E_b = 1 \times 10^5$ N/mm^2 $\alpha s = 11.6 \times 10^{-6}$/°C and $\alpha b = 18.7 \times 10^{-6}$/°C. (14 marks)

Module 2

13) Determine the stress invariants, principal stresses and principal directions from the stress matrix at a point on a submarine hull given as follows: (14 marks)

$$\begin{bmatrix} 8 & 0 & 6 \\ 0 & 5 & 0 \\ 6 & 0 & -8 \end{bmatrix} \text{MPa}$$

OR

14) At a point in a bracket the stresses on two mutually perpendicular planes are 140 N/mm^2 and 70 N/mm^2 both tensile. The shear stress across these planes is 30 N/mm^2. Using the Mohr's stress circle determine the

i. principal stresses
ii. maximum shear stress
iii. principal planes and
iv. plane of maximum shear stress. (14 marks)

Module 3

15) a) What are the assumptions taken while deriving Torsion equation (4 marks)

b) A solid aluminum shaft 1.5 m long and 60 mm diameter is to be replaced by a tubular steel shaft of the same length and the same outside diameter such that each of the two shafts could have the same angle of twist per unit torsional moment over the total length. What must the inner diameter of the tubular steel shaft be? Modulus of rigidity of the steel is three times that of aluminium. (10 marks)

OR

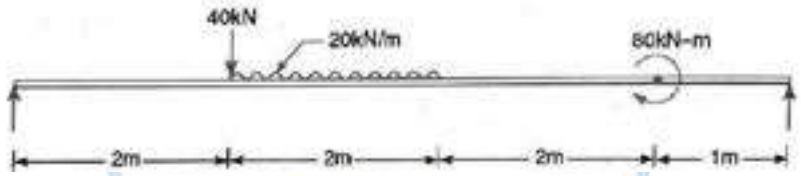
16) A 1.5 m long column has a circular cross section of 5 cm diameter. One of the ends of the column is fixed in direction and position and other end is free. Taking factor of safety as 3, calculate the safe load using

(i) Rankine's formula, take yield stress as 560 N/mm^2 and $\alpha = 1/1600$ for pinned ends and

(ii) Euler's Formula, Take E = 1.2 x10^5 N/mm^2. (14 marks)

Module 4

17) Draw the shear force and bending moment diagrams for the simply supported beam shown in the figure. Calculate and locate the position of maximum bending moment. (14 marks)



OR

18) A simply supported beam of 8 m length carries two point loads of 64 kN and 48 kN at 1 m and 4 m, respectively, from the left-hand end. Find the deflection under each load and the maximum deflection using Macauley's method. Take E = 210 GPa and $I = 180 \times 10^6$ mm^4. (14 marks)

Module 5

19) Determine the diameter of a bolt which is subjected to an axial pull of 9 kN together with a transverse shear force of 4.5 kN. Using

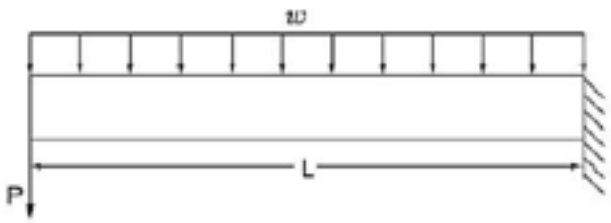
a. Maximum shear stress theory
b. Maximum strain energy theory
c. Maximum shear strain energy theory

Yield stress corresponding to elastic limit is 225 MPa,
Factor of Safety = 3, and Poisson's ratio = 0.3 (14 marks)

OR

20) a) Derive the expression for strain energy due to bending. (4 marks)

b) The cantilever beam supports a uniformly distributed load w and a concentrated load P as shown in figure. Also, it is given that L= 2 m, w = 4 kN/m, P = 6 kN and EI = 5 MNm^2. Determine the deflection at the free end using Castigliano's theorem. (10 marks)



B24MEM32	FLUID MECHANICS AND MACHINERY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course covers the fundamental principles of fluid mechanics and hydraulic machinery. Topics include fluid properties, fluid statics, and dynamics, including Bernoulli's and Euler's equations. The course also explores boundary layer concepts, closed conduit flow, and the measurement of flow using various devices. Additionally, the design and application of hydraulic turbines and pumps are discussed, including their performance characteristics and selection criteria. By the end of this course, students will have a comprehensive understanding of fluid mechanics and its practical applications in hydraulic machinery.

Prerequisite

Nil

Course Outcomes

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

CO 1	Explain the characteristics of fluids and solve hydrostatic problems. (Cognitive knowledge level: Understand)
CO 2	Outline different approaches to fluid kinematics and classify fluid flows. (Cognitive knowledge level Understand)
CO 3	Apply Euler equation and Bernoulli’s equation to the fluid flow problems. (Cognitive knowledge level: Apply)
CO 4	Make use of geometric similarity and unit-specific quantities to design and select suitable hydraulic turbines for specific hydro-power plant application. (Cognitive knowledge level: Apply)
CO 5	Utilize the principles of pump operation to design, select, and evaluate the suitability of centrifugal and reciprocating pumps. (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	1						1			1
CO 2	3	2	1	1					1			1
CO 3	3	3	1	2					1			1
CO 4	3	3	2	1					1			1
CO 5	3	2	1	2					1			1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	10	10
Understand	60	30	30
Apply		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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

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SYLLABUS

MODULE 1 (9 hours)

Introduction: Fluids and continuum, Physical properties of fluids, density, specific weight, vapour pressure, Newton's law of viscosity. Ideal and real fluids, Newtonian and non-Newtonian fluids. Fluid Statics- Pressure-density-height relationship, measurement of pressure – Piezometer, U tube and differential manometers

MODULE 2 (9 hours)

Eulerian and Lagrangian approaches, Stream line, path line and streak lines and stream tube, velocity and acceleration in fluid. classification of flows-steady & unsteady, uniform, non-uniform, laminar, turbulent, rotational, and irrotational flows-equation of continuity for one dimensional flow. Surface and body forces –Euler's and Bernoulli's equations for flow along a stream line, momentum equation and its application on force on pipe bend. Navier-Stokes Equation Introduction only.

MODULE 3 (9 hours)

Boundary Layer Concept: Definition, thickness, characteristics along thin plate, laminar and turbulent boundary layers (No derivation). Closed conduit flow: Reynold's experiment- Darcy Weisbach equation- Major and Minor losses – pipes in series and pipes in parallel- total energy line-hydraulic gradient line. Measurement of flow: Pitot tube, Venturi meter and Orifice meter

MODULE 4 (9 hours)

Classification of turbines, design of Pelton wheel, Francis turbine and Kaplan turbine–working proportion, work done, efficiency, draft tube-theory, functions and efficiency. Geometric similarity, Unit and specific quantities,
characteristic curves, selection of type of turbine, cavitation, surge tank and water hammer, elements of hydro power plant.

MODULE 5 (9 hours)

Classification, centrifugal pumps–types, working, work done, monomeric head, losses and efficiency, specific speed – pumps in series and parallel – performance characteristic curves, NPSH, Reciprocating Pump – types, Working, Discharge, slip, indicator diagrams. Air vessels and its purpose

Text Books

1. Hydraulics and Fluid mechanics including Hydraulic Machines, Modi and Seth, 21st
2. Introduction to Fluid Mechanics, R. W. Fox, A. T. McDonald, 2001.
3. Subramanya K. Fluid Mechanics & Hydraulic Machines. Tata McGraw-Hill Education; 2001.
4. Bansal RK. Fluid mechanics and hydraulic machines. 2011.

Reference Books

1. White, F. M., Fluid Mechanics, McGraw Hill Education India Private Limited, 8th Edition, 2017
2. Rathakrishnan, E. Fluid Mechanics: An Introduction, Prentice Hall India, 3rd Edition 2012.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**9**
1.1	Introduction: Fluids and continuum, Physical properties of fluids, density, specific weight, vapour pressure.	3
1.2	Newton's law of viscosity. Ideal and real fluids, Newtonian and non-Newtonian fluids.	3
1.3	Fluid Statics- Pressure-density-height relationship, measurement of pressure – Piezometer, U tube and differential manometers.	3
	Module 2	**9**
2.1	Kinematics of fluid flow: Eulerian and Lagrangian approaches.	3
2.2	Stream line, path line and streak lines and stream tube, velocity and acceleration in fluid.classification of flows-steady & unsteady, uniform, non-uniform, laminar, turbulent, rotational, and irrotational flows	3
2.3	Continuity equation for one dimensional flow Surface and body forces –Euler's and Bernoulli's equations for flow along a stream line, momentum equation and its application on force on pipe bend. Navier-Stokes Equation Introduction only.	3
	Module 3	**9**
3.1	Boundary Layer Concept: Definition, thickness, characteristics along thin plate, laminar and turbulent boundary layers (No derivation)	3
3.2	Closed conduit flow: Reynold's experiment- Darcy Weisbach equation- Major and Minor losses – pipes in series and pipes in parallel-total energy line-hydraulic gradient line	3
3.3	Dynamics of Fluid flow: Bernoulli's equation. Measurement of flow: Pitot tube, Venturi meter and Orifice meter	3
	Module 4	**9**
4.1	Classification of turbines, design of Pelton wheel, Francis turbine and Kaplan turbine–working proportion, work done, efficiency, draft tube-theory, functions and efficiency	3
4.2	Geometric similarity, Unit and specific quantities, characteristic curves, selection of type of turbines	3
4.3	Cavitation, surge tank and water hammer, elements of hydro power plant	3
	Module 5	**9**
5.1	Classification, centrifugal pumps–types, working, work done, monomeric head, losses and efficiency.	3
5.2	specific speed – pumps in series and parallel – performance characteristic curves, NPSH	3
5.3	Reciprocating Pump – types, Working, Discharge, slip, indicator diagrams. Air vessels and its purpose.	3
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. A cylinder 0.12m radius rotates concentrically inside a fixed cylinder of 0.13 m radius. Both cylinders are 0.3m long. Determine the viscosity of liquid which fills the space between the cylinders, if A torque of 0.88 Nm is required to maintain an angular velocity of 2 π rad / sec.

2. A stationary liquid is stratified so that its density is $\rho 0(1+h)$ at a depth h below the free surface. At a depth h in this liquid, what is the pressure in excess of $\rho 0gh$?

3. If the velocity profile of a fluid is parabolic with free stream velocity 120 cm/s occurring at 20 cm from the plate, calculate the velocity gradients and shear stress at a distance of 0, 10, 20 cm from the plate. Take the viscosity of fluid as 8.5 poise.

Course Outcome 2 (CO2):

1. Differentiate between Eulerian and Lagrangian method of representing fluid motion.

2. A velocity field is given by $u=3y^2$, $v=2x$ and $w = 0$ in arbitrary units. Is this flow steady or unsteady?
   Is it two or three dimensional? At (x, y, z) = (2,1,0), compute

   a. velocity
   b. local acceleration
   c. convective acceleration

3. What is Euler's equation of motion? How will you obtain Bernoulli's equation from it?

Course Outcome 3 (CO3):

1. Two reservoirs are connected by a pipe line consisting of two pipes, one of 15cm diameter and length 6m and the other diameter 22.5cm and 16m length. If the difference of water levels in the two reservoirs is 6m. Calculate the discharge and draw the energy gradient line. Take f=0.004

2. Derive the Euler's equation of motion along a streamline and from that derive the Bernoulli's equation.

3. What is Venturi meter? Derive the expression for Coefficient of discharge for Venturi meter

Course Outcome 4 (CO4):

1. A Pelton wheel has a mean bucket speed of 10m/s with a jet of water flowing at the rate of 700 Litre/sec under a head of 30 m. the buckets deflect the jet through an angle of 1600 calculate the power given by the water to the runner and hydraulic efficiency of the turbine? Assume co-efficient of velocity=0.98.

2. Prove that the force exerted by a jet of water on a fixed semi-circular plate in the direction of the jet when the jet strikes at the centre of the semi-circular plate is two times the force exerted by the jet on an fixed vertical plate.

3. (a) What are the unit quantities used to analyse the performance of hydraulic turbines. Explain its importance.
   (b) What is specific speed of a turbine.

Course Outcome 5 (CO5)

1. A centrifugal pump discharges 0.15 m^3/s of water against a head of 12.5 m, the speed of the impeller being 600 r.p.m. The outer and inner diameters of impeller are 500 mm and 250 mm respectively and the vanes are bent back at 35° to the tangent at exit. If the area of flow remains 0.07 m^2 from inlet to outlet, calculate.

   (a) Manometric efficiency of pump,
   (b) Vane angle at inlet, and
   (c) Loss of head at inlet to impeller when discharge is reduced by 40% without changing the speed.

2. (a) What is slip in a reciprocating pump. What is the reason for negative slip in a reciprocating pump.

   (b) A single acting reciprocating pump having a bore of 150 mm and a stroke of 300 mm length, discharges 250 l of water per minute at 50 rpm. Neglecting losses, find theoretical discharge and slip of the pump.

   (c) With a neat sketch explain the working of a gear pump. Explain the importance of dimensionless numbers and discuss any two similarity laws. Where are these model laws used?

3. Explain the following terms as they are applied to a centrifugal pump:

   (a) Static suction lift,
   (b) static suction head,
   (c) static discharge head and
   (d) total static head.

KNOWLEDGE IS POWER

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

THIRD SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: **B24MEM32**

Course Name: **FLUID MECHANICS AND MACHINERY**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. The specific gravity of a liquid is 3.0. What are its specific weight, specific mass, specific volume.
2. State Pascal's law and give some examples where this principle is used.
3. Explain Streamlines, Streak lines and Path lines.
4. Define and distinguish between steady flow and uniform flow. Give two examples of each flow
5. Define the following terms (i) Total Energy line (ii) Hydraulic Gradient line
6. 6. Differentiate between pitot tube and pitot static tube.
7. What is degree of reaction? What will be the degree of reaction for a Pelton wheel.
8. Explain speed ratio and jet ratio.
9. Define slip, percentage slip and negative slip of a reciprocating pump.
10. What is the purpose of air vessels in multi-cylinder reciprocating pump.

PART B

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

Module 1

11.a) The space between two parallel square plates each of side 0.8m is filled with an oil of specific gravity 0.8. If the space between the plates is 12.5mm and the upper plate which moves with velocity of 1.25m/s requires a force of 51.2 N. Determine (i) Dynamic viscosity of oil in poise (ii) Kinematic viscosity in stokes. (7 marks)

.

b) A U- tube mercury manometer is used to measure the pressure of oil flowing through a pipe whose specific gravity is 0.85. The center of the pipe is 15 cm below the level of mercury. The mercury level difference in the manometer is 25 cm, determine the absolute pressure of the oil flowing through the pipe. Atmospheric pressure is 750 mm of Hg. (7 marks)

OR

12.a) Two large planes are parallel to each other and are inclined at 30° to the horizontal with the space between them filled with a fluid of viscosity 20 cp. A small thin plate of 0.125 m square slides parallel and midway between the planes and reaches a constant velocity of 2 m/s. (7 marks)

b) A spherical water drop of 1 mm diameter splits up in air into 64 smaller drops of equal size. Find the work required in splitting up the drop. The surface tension coefficient of water in air = 0.073 *N/m.* (7 marks)

Module 2

13.a) What is Euler's equation of motion? How to obtain Bernoulli's equation from it? (10 marks)

b) Explain the assumptions of Bernoulli's Equation. (4 marks)

OR

14.a) The velocity vector in a fluid flow is given by $v=4x^3i-10x^2y^2j+2tk$ find the velocity and acceleration of a fluid particle at (2,1,3) at time t=1 (10 marks)

b) Explain Rotational flow and Irrotational flow. (4 marks)

Module 3

15.a) A submarine moves horizontally in sea and has its axis 15 m below the surface of the water. A pitot tube properly placed just in front of the submarine and along its axis is connected to two limbs of a U tube containing mercury. The difference of level is found to be 170 mm. Find the speed of the submarine knowing that the specific gravity of mercury is 13.6 and that of sea water is 1.026 with respect to water. (7 marks)

b) A pitot tube is inserted in a pipe of 30 cm diameter. The static pressure of the tube is 10 cm of mercury vacuum. The stagnation pressure at the centre of the pipe recorded by the pitot tube is 1.0 $N=cm^2$. Calculate the rate of flow of water through the pipe, if the mean velocity of flow is 0.85 times central velocity. Assume coefficient of tube as 0.98. (7 marks)

OR

16.a) Derive Hagen-Poiseuille equation from the fundamentals and state the assumptions made (7 marks)

b) Petrol of specific gravity 0.8 is following through a pipe of 30 cm diameter. The pipe is inclined at 30° to horizontal. The venturi has a throat diameter of 10 cm. U tube

manometer reads 6.25 cm Hg. Calculate the discharge through the pipe. Assume Cd = 0.98. (7 marks)

Module 4

17.a) A Francis turbine with an overall efficiency of 75% is required to produce 148.25kW power. It is working under a head of 7.62m. The peripheral velocity=$0.26\sqrt{2gh}$ and the radial velocity of flow at inlet is $0.96\sqrt{2gh}$. The wheel runs at 150rpm and the hydraulic losses in the turbine are 22% of the available energy. Assuming radial discharge determine

i. The guide blade angle.

ii. The wheel vane angle at inlet

iii. The diameter of the wheel at inlet, and

iv) Width of the wheel at inlet (8 marks)

b). Explain the theory of Draft Tube. (6 marks)

OR

18. a) A Pelton wheel has a mean bucket speed of 10 m/s with a jet of water flowing at the rate of 700 litres/s under a head of 30 m. The buckets deflect the jet through an angle of 160°. Calculate the power given by the water to the runner and the hydraulic efficiency of the turbine. Assume coefficient of velocity as 0.98. (7 Marks)

b) A Kaplan turbine runner is to be designed to develop 7357.5 kW shaft power. The net available head is 10 m. Assume that the speed ratio is 1.8 and flow ratio is 0.6. If the overall efficiency is 70% and diameter of the boss is 0.4 times the diameter of the runner, find the diameter of the runner, its speed and specific speed. (7 Marks)

Module 5

19. a) A centrifugal pump having outer diameter equal to two times the inner diameter and running at 1200 rpm works under total head of 32m. The velocity of flow through the impeller is constant and equal to 3m/sec. The vanes are set back at an angle of 30° at the outlet. If the outer diameter of the impeller is 600mm and width at outlet is 50mm, determine (i) vane angle at inlet (ii) work done per sec by the impeller (iii) manometric efficiency. (7 marks)

b) Derive an expression for the minimum starting speed of a centrifugal pump (7 marks)

OR

20.a) Draw an indicator diagram, considering the effect of acceleration and friction in suction and delivery pipes. Find the expression for work done per second in the case of single acting reciprocating pump. (7 marks)

b) A double acting reciprocating pump, having cylinder diameter 15 cm and stroke length 30 cm is used raise the water through a height of 30 meters. If the pump is working at 30rpm and the pump efficiency is 73%o, what power is required to drive the pump? (7 marks)

B24MEM33	MATERIAL SCIENCE & TECHNOLOGY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course will help the student understand the relationship between chemical bonds and the crystal structures of metallic materials. It will enable them to recognize the significance of crystal imperfections, such as dislocations, in plastic deformation. The course will also guide the student in examining the mechanisms of material failure through fatigue and creep. Additionally, it will provide them with a solid grasp of the fundamental characteristics, properties, and applications of various engineering materials.

Prerequisite

NIL

Course Outcomes

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

CO 1	Interpret the atomic bonding & crystal structures which reveals their relationship with the properties. (Cognitive Knowledge Level: Understand)
CO 2	Explain the fundamental principles of strengthening mechanisms in metallurgy. (Cognitive Knowledge Level: Understand)
CO 3	Identify the factors that influence fatigue failures like material properties, stress concentrations, environmental conditions and loading conditions. (Cognitive Knowledge Level: Apply)
CO 4	Understand the different types of engineering materials used for industrial and daily life applications. (Cognitive Knowledge Level: Understand)
CO 5	Outline the general properties of engineering materials that are important for design and applications. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6		PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	2	1	1									
CO 2	2	2	1	1						1		1
CO 3	2	2	2			1						
CO 4	2	2	2	1	2				1			2
CO 5	1	2	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	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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

KNOWLEDGE IS POWER

SYLLABUS

MODULE 1 (8 hours)

Introduction to material science - Fundamental concept of atomic structure – Atomic Bonding in solids, Classifications of Engineering Materials, Crystallography - SC, BCC, FCC, HCP structures, APF - theoretical density - property relationships in materials

MODULE 2 (9 hours)

Miller Indices: - crystal plane and direction, Crystal imperfections – Classifications and examples, Diffusion in solids, fick's laws - Applications of diffusion - dislocation density, mechanism of crystallization: homogeneous and heterogeneous nuclei formation, Hall - Petch theory.

MODULE 3 (8 hours)

Strengthening mechanisms- Overview of Strengthening Mechanisms, Types of Strengthening Mechanisms, Fracture:- Introduction to Fracture, Types of fracture - brittle and ductile fracture - DBTT, Fatigue - Stress cycles, S-N Curve, fatigue tests, Factors Affecting Fatigue Life, Creep- Creep curves, creep tests, Applications and Challenges

MODULE 4 (10 hours)

Composites – Introduction of composites, Need of development of composites - fiber and matrix phase - polymer matrix composites - metal matrix composites - ceramic matrix composites, Engineering Materials:- Ferrous and Non Ferrous materials, Plastic:- types, Properties and its applications

MODULE 5 (10 hours)

Mechanical Properties - Overview of mechanical properties and their significance in materials including Elastic and Plastic deformation, Tensile, Hardness, Machinability, formability and weldability.

Electrical Properties - Introduction to the fundamental concepts, exploring charge carriers, conductivity, resistivity, and the role of energy band structures in materials, classification of electrical properties, including conductors, semiconductors and insulators.

Corrosion and Degradation of Materials - Introduction to the fundamental concepts of corrosion, including its definition, significance, and economic and safety implications in various industries, corrosion rate, different types of corrosion.

Text Books

1. Callister William. D, Material Science and Engineering, John Wiley, 2014
2. Raghavan V, Material Science and Engineering, Prentice Hall, 2004

Reference Books

1. Introduction to Engineering Materials, B. K. Agrawal, Tata McGraw Hill Education Private Limited
2. Dieter George E, Mechanical Metallurgy, Tata McGraw Hill, 1976
3. Anderson J.C. *et.al*., Material Science for Engineers, Chapman and Hall, 1990

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module1	**8**
1.1	Introduction to Material Science and Science - Atomic structure and bonding –Ionic, covalent and Metallic bonding, its properties - correlation of atomic radius to strength; electron configurations	2
1.2	Secondary bonds – van der walls bonding, Classifications of Engineering Materials – Specific heat, applications	2
1.3	Crystallography – Crystal, Space lattice, Unit cells:- SC, BCC, FCC and HCP unit cells, Calculation of number of atoms per unit cell and its relation to density	2
1.4	Coordination Number - Atomic Packing Factor - theoretical density – Simple problems, Polymorphism and allotropy.	2
	Module 2	**9**
2.1	Miller indices: - crystal plane and direction	2
2.2	Modes of plastic deformation- Slip and twinning	1
2.3	Attributes of miller indices for slip system, brittleness of BCC, HCP and ductility of FCC	1
2.4	Classification of crystal imperfections;- 0-D, 1-D and 2-D and 3D defects	2
2.5	Diffusion in solids, fick's laws, mechanisms, applications - dislocation density	1
2.5	Mechanism of crystallization, Homogeneous and heterogeneous nuclei formation, under cooling, dendritic growth, grain boundary irregularity. Hall – Petch theory	2
	Module 3	**8**
3.1	Strengthening mechanisms:- Overview of Strengthening Mechanisms, Types of Strengthening Mechanisms-solid-solution strengthening, precipitation, grain refinement and work hardening	2
3.2	Fracture:-Types of fracture - brittle and ductile fracture - DBTT	1
3.3	Fatigue: - Stress cycles – Primary and secondary stress raisers	2
3.4	Characteristics of fatigue failure, fatigue tests, S-N curve attributes.	1
3.5	Factors Affecting Fatigue Life	1
3.5	Creep: - Creep curves, creep tests, Applications and Challenges	1
	Module 4	**10**
4.1	Composites: - Need of development of composites; fiber phase; matrix phase; only need and characteristics of PMC, MMC, and CMC.	2
4.2	Modern engineering materials: - Ferrous materials - Steels, Plain carbon steel, Alloy Steel, Maraging steels, Stainless steels, Tool steels, Cast iron (only fundamentals)	2
4.3	Non-ferrous materials: Aluminium alloys, Copper alloys, Magnesium alloys, Titanium alloys, super alloys (only fundamentals)	2
4.4	Plastics – Introduction to plastic, Chemistry of plastic.	2

	Types of plastic - Thermosetting and thermoplastic materials, Properties and applications	2
	Module 5	**10**
5.1	Overview of different properties of engineering materials and its importance, Classifications	1
5.2	Mechanical Properties of Materials- Elastic deformation, Plastic deformation, Tensile strength and Hardness, Machinability, formability and weldability	2
5.3	Electrical Properties of Materials: Introduction to the fundamental concepts, role of energy band structures in materials	1
5.4	Exploring charge carriers Resistivity, conductivity, Semiconductors, Dielectric, Ferroelectric and Piezoelectricity	2
5.5	Corrosion and Degradation of Materials – Definition, Factors affecting corrosion and degradation, Corrosion rate	2
5.6	Types of corrosion – Crevice Corrosion, Stress Corrosion, Intergranular Corrosion, Galvanic Corrosion, Pitting Corrosion, Uniform Corrosion	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Which are the characteristics of ionic crystal
2. What is co-ordination Number
3. Define Fick's First law of diffusion
4. Explain why covalently bonded materials are generally less dense than ionically or metallically bonded ones

Course Outcome 2 (CO2):

1. What is the driving force for recrystallisation and grain growth of metallic crystals
2. Define Hall-Petch theory
3. What are the roles of surface defects on crack propagation

Course Outcome 3 (CO3):

1. Compare interstitial and vacancy mechanisms for diffusion.
2. Explain the effect of impact loading on ductile materials
3. Explain the factors affecting the fatigue strength

Course Outcome 4 (CO4):

1. Define Composites? How they are classified?
2. List three functions of the matrix phase in a polymer-matrix fiber-reinforced composite.
3. Explain the importance of all the non-ferrous alloys in automotive applications.

Course Outcome 5 (CO5):

1. What is the difference between normal stress and shear stress?
2. How does temperature affect the conductivity of metals and semiconductors?
3. What is the role of grain size in determining the strength of a material?

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

THIRD SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: **B24MEM33**

Course Name: **MATERIAL SCIENCE AND TECHNOLOGY**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Which are the characteristics of ionic crystal?
2. What are the lattice parameters that define a unit cell? List them.
3. What is co-ordination Number?
4. What is Hall-Petch Theory.
5. Compare interstitial and vacancy mechanisms for diffusion.
6. Discuss two basic modes of plastic deformation.
7. What is the main difference between plain carbon steel and alloy steel?
8. Define Composites? How they are classified?
9. What is corrosion, and why does it occur?
10. What is superconductivity, and how is it different from perfect conductivity?

PART B

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

Module 1

11. a) Explain Bohr's model and Rutherford's atomic model. (6)

    b) Describe about secondary bonds. (8)

OR

12. Prove that FCC is closely packed than BCC by calculating atomic packing factor of both. (14)

Module 2

13. a) What are crystallographic planes? How Miller indices for planes can be determined? (6)

    b) Explain about the types of surface defects (8)

OR

14. a) Brief about slip and twinning. (6)

    b) Distinguish between homogeneous and heterogeneous nuclei formation. (8)

Module 3

15. a) How do ductile and brittle fractures differ from each other? (8)

    b) Discuss the importance of ductile to brittle transition temperature. (6)

OR

16. a) What are the different regions in the creep curve? Explain each region. (7)

    b) With the help of a simple sketch, explain fatigue test. (7)

Module 4

17. a) Explain fibre reinforced composites (7)

    b) What is polymer matrix composite? Explain its types. (7)

OR

18. a) Explain ceramic matrix composite. Mention any two applications. (7)

    b) Explain the classification of ferrous materials and their key properties. (7)

Module 5

19. a) What is hardness, and how is it measured? Compare the applications of materials with varying hardness levels. (8)

    b) What is superconductivity? Describe its key characteristics. (6)

OR

20. a) What are the challenges in developing materials with both high strength and excellent electrical conductivity? (8)

    b) What is the significance of the modulus of elasticity (Young's modulus) in engineering? Explain its role in material selection (6)

MAR ATHANASIUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution
Kothamangalam, Kerala, India

B.TECH MECHANICAL ENGINEERING

SEMESTER 4

SYLLABUS

SEMESTER 4

SLOT	COURSE NO.	COURSES	L-T-P-S	HOURS	CREDIT
A	B24MA2T04B	STATISTICAL ANALYSIS AND NUMERICAL METHODS	3-1-0-5	4	4
B	B24ME2T04	THEORY OF MACHINES	3-1-0-5	4	4
C	B24ME2T05	METROLOGY AND MACHINE TOOLS	3-1-0-4	4	3
D	B24ME2T06	ENGINEERING THERMODYNAMICS	3-1-0-5	4	4
E	B24HU2T01	BUSINESS ECONOMICS AND FINANCIAL MANAGEMENT	3-0-0-4	3	3
F	B24ME2T07	FLUID MACHINES	2-1-0-4	3	3
G	B24ME2L04	MECHANICAL MEASUREMENTS LAB	0-0-3-2	3	2
H	B24ME2L05	FLUID MECHANICS AND MACHINES LAB	0-0-3-2	3	2
M	B24MEM4x	MINOR	3-1-0-5	4	4
N	B24MEH4x	HONOURS	3-1-0-5	4	4
			TOTAL*	**36**	**25**

* Semester total does not include the credits of honors and minor courses

MINOR COURSES

BASKET	COURSE NO.	COURSE NAME
BASKET I (DESIGN)	B24MEM41	MECHANICS OF MACHINES
BASKET II (THERMAL)	B24MEM42	THERMODYNAMICS
BASKET III (PRODUCTION)	B24MEM43	MANUFACTURING PROCESS

HONOURS COURSES

GROUP	COURSE NO.	COURSE NAME
GROUP I (DESIGN)	B24MEH41	DESIGN OF HYDRAULIC AND PNEUMATIC EQUIPMENTS
GROUP II (THERMAL)	B24MEH42	ADVANCED FLUID MECHANICS
GROUP III (PRODUCTION)	B24MEH43	ADVANCED ENGINEERING MATERIALS

B24MA2T04B	STATISTICAL ANALYSIS AND NUMERICAL METHODS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble:

This course aims to introduce students to the modern theory of probability and statistics covering important models of discrete and continuous random variables. It also covers techniques of parameter estimation and hypothesis testing. 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	Perform statistical inferences concerning characteristics of a population based on attributes of samples drawn from the population (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. (Cog- nitive Knowledge Level: Apply)

Mapping of Course Outcomes With Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	1		1							
CO2	2	1		1		1					
CO3	2	1		1							
CO4	1	2		1	1						1
CO5	1	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	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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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: Discrete probability distributions(9 hours)

(Text 1: Relevant topics from sections 3.1-3.4, 3.6, 5.1)

Discrete random variables and their probability distributions, Expectation, mean and variance, Binomial distribution, Poisson distribution, Poisson approximation to the binomial distribution,Discrete bivariate distributions, marginal distributions, Independent random variables, Expectation -multiple random variables

MODULE:2 Continuous probability distributions (9 hours)

(Text 1 : Relevant topics from sections 4.1-4.4, 3.6,5.1)

Continuous random variables and their probability distributions, Expectation, mean and variance, Uniform, exponential , normal distributions , Continuous bivariate distributions, marginal distributions, Independent random variables, Expectation-multiple random variables, i.i.d random variables and Central limit theorem (without proof)

MODULE 3 :Testing of Hypothesis (9 hours)

(Text 1 : Relevant topics from sections 3.6, 5.1, 5.4,7.2, 8.1, 8.3, 9.1,9.2,9.4)

Population and samples, Sampling distribution of the mean and proportion, Confidence interval for single mean and single proportions. Test of hypotheses: Large sample test for single mean and single proportion, equality of means and equality of proportions of two populations, small sample t-tests for single mean of normal population, equality of means.

MODULE: 4 Numerical methods -I(9 hours)

(Text 2 : Relevant topics from sections 19.1, 19.2, 19.3, 19.5)

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 Numerical methods -II(9 hours)

(Text 2 : Relevant topics from sections 20.3, 20.5, 21.1)

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. (Text-1) Jay L. Devore, Probability and Statistics for Engineering and the Sciences, 8^{th} edition, Cengage, 2012

2. (Text-2) Erwin Kreyszig, Advanced Engineering Mathematics, 10^{th} Edition, John Wiley Sons, 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. Sheldon M. Ross, Introduction to probability and statistics for engineers and scientists, 4th edition, Elsevier, 2009.

3. T. Veera Rajan, Probability, Statistics and Random processes, Tata McGraw-Hill, 2008

4. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36 Edition, 2010.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No of Lecture/Tutorial Hours
1	**Module 1: Discrete Probability distributions**	**9**
1.1	Discrete Probability distributions	3
1.2	Binomial distribution-mean, variance, Poisson distribution-mean, variance, Poisson approximation to binomial	3
1.3	Discrete bivariate distributions, marginal distributions, Independence of random variables (discrete), Expected values	3
2	**Module 2: Continuous Probability distributions**	**9**
2.1	Continuous random variables and probability distributions, expected value, mean and variance .	2
2.2	Uniform, exponential and normal distributions, mean and variance of these distributions	4

2.3	Continuous bivariate distributions, marginal distributions, Independent random variables, Expected values, Central limit theorem.	3
3	**Module 3: Testing of Hypothesis**	**9**
3.1	Population and samples, Sampling distribution of single mean and single proportion	1
3.2	Confidence interval for single mean and single proportions	2
3.3	Hypothesis testing basics, large sample test for single proportion, single proportion	2
3.4	Large sample test for equality of means and equality of proportions of two populations	2
3.5	t-distribution and small sample t-test for single mean and pooled t test for equality of means	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 1/3-rd rule	2
5	**Module 5: Numerical methods-II**	**9**
5.1	Solution of linear systems-Gauss-Siedal 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
	Total	**45 Hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO 1):Understand the concept, properties and important models of discrete random variables and, using them, analyse suitable random phenomena. .

1. The probability that a batsman scores a century in a cricket match is $\frac{1}{3}$. Find the probability that out of 5 matches, he may score century in (i) at least 2 matches (ii) at most 2 matches (iii) no match.
2. Three balls are drawn at random without replacement from a box containing 2 white, 3 red and 4 black balls. If X denotes the number of white balls drawn and Y denotes the number of red balls drawn, find the joint probability distribution of (X, Y)
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): Understand the concept, properties and important models of continuous random variables and, using them, analyse suitable random phenomena

1. A random variable has a normal distribution with standard deviation 10. If the probability that it will take on a value less than 82.5 is 0.82, what is the probability that it will take on a value more than 58.3?
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. Verify whether X and Y are independent if $f(x, y) = 24xy, 0 \leq x \leq 1, 0 \leq y \leq 1, 0 \leq x + y \leq 1$.

Course Outcome 3 (CO 3): Analyse stochastic processes using autocorrelation, power spectrum and understand multivariable probability distribution.

1. In a random sample of 500 people selected from the population of a city 60 were found to be left-handed. Find a 95% confidence interval for the proportion of lefthanded people in the city population.
2. A magazine reported the results of a telephone poll of 800 adult citizens of a country. The question posed was: "Should the tax on cigarettes be raised to pay for health care reform?" The results of the survey were: Out of the 800 persons surveyed, 605 were non-smokers out of which 351 answered "yes" and the rest "no". Out of the remaining 195, who were smokers, 41 answered "yes" and the remaining "no". Is there sufficient evidence, at the 0.05 significance level, to conclude that the two populations smokers and non-smokers differ significantly with respect to their opinions?
3. A sample of 20 items has mean 42 and SD 5. Test whether the sample is from a population with mean 45? (5 % level of significance)

Course Outcome 4 (CO 4): Compute roots of equations, evaluate definite integrals and perform interpola- tion on given numerical data using standard numerical techniques.

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):Apply standard numerical techniques for solving systems of equations, fitting curves on given numerical data and solving ordinary differential equations.

1. Solve the equations using Gauss Seidal method

   $x + 2y + z = 3$
   $2x + 3y + 2z = 5$
   $3x - 5y + 5z = 2$
   $3x + 9y - z = 4$

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 $y = a + bx$.

MODEL QUESTION PAPER

QP CODE: **Pages: 2**

Reg.No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FOURTH SEMESTER B.TECH DEGREE EXAMINATION, JUNE 2025

Course Code: B24MA2T04B

Course Name: STATISTICAL ANALYSIS AND NUMERICAL METHODS

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. Life time of a particular variety of bulbs is a random variable with mean 1200 hrs and S.D. 250 hrs. Use Central Limit Theorem to find the probability that average life time of 60 bulbs exceeds 1250 hrs
5. For the population of individuals who own iPhone, $p = 0.25$ is the proportion that has a given app. For a random sample of size $n = 4$, find mean and standard deviation of the sampling distribution of the population proportion
6. If the mean age of 64 men engaged in an occupation is 52.4 years with S.D 10.2 years, construct 90% confidence limit for the mean age of all men in that occupation.
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. Obtain the values of y in $x = 0.1$ using the Runge- Kutta method of second order for the differential equation$y' = -y, y(0) = 1$

PART B

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

Module 1

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

    (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

OR

12. (a) A Random variable X has the following probability distribution function.

X	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Y	a	$3a$	$5a$	$7a$	$9a$	$11a$	$13a$	$15a$	$17a$

    Determine (i) the value of a (ii) $P(\text{X}\leq 3)$ (iii) $P(\text{X}\geq 3)$(iv) $P(4 \leq \text{X} \leq 7)$ 7

    (b) The joint probability mass function of X and Y is given by $p(x, y) = (x + 2y) \div 18$ if $(x, y) = (1, 1), (1, 2), (2, 1), (2, 2)$. Find (i) Marginal distributions (ii) Verify whether X and Y are independent.

    7

Module 2

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

    (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

OR

14. (a) The time in hours required to repair a machine is exponentially distributed with mean 20. What is the probability that the required time (i) exceeds 30 hours? (ii) between 16 hours and 24 hours? 7

    (b) .The joint PDF of continuous random variable X and Y is given by

    $$f(x,y) = \begin{cases} kxy, 0 \leq x \leq 4, 1 \leq y \leq 5 \\ 0, otherwise \end{cases}$$

    Find (i) the value of k (ii) $P(X > 3, Y < 4$ (iii) marginal distributions (iv) Check whether X and Y are independent. 7

Module 3

15. (a) A die is thrown 9000 times and 3220 times shown 5 or 6. Is the die unbiased at 5% level of significance? 7

(b) A random sample of size 6 has mean 25 and variance 3.83. Can the sample be regarded as taken from a population with mean lesser than 29 at 1% level of significance?. 7

OR

16. (a) The mean weight obtained from a random sample of size 100 is 64 gm. The standard deviation of the weight distribution of the population is 3 gm. Test the statement that the mean weight of the population is 67 gm at 5% level of significance 7

(b) The average marks scored by 50 students of class A is 42.75 with variance 1.98. The average marks scored by 60 students of class B is 42.15 with variance 1.82. Based on this data can we conclude that students of class A perform better than students of class B at at 5% level of significance level?

7

Module 4

17. (a) Use Lagrange's interpolation formula to find $y(2)$ from the following table

X	1	3	4
Y	1	27	64

7

(b) Find the positive root of the equation $x^3 + x + 1 = 0$ using Newton-Raphson method correct to 4 decimal places. 7

OR

18. (a) Evaluate $\int_0^2 xe^x dx$ using Simpson's $\frac{1}{3}$rd rule with $n = 8$. 7

(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

Module 5

19. (a) Solve by Gauss-Seidel method the following system :
$28x + 4y - z = 32$
$x + 3y + 10z = 24$
$2x + 17y + 4z = 35$

7

(b) Fit a straight line to the points (0,2), (2,0), (3, −2) , (5, −3) using method of least squares. 7

OR

20. (a) Apply Gauss-Seidel method to solve the equations $20x + y - 2z = 17$
$3x + 20y - z = -18$
$2x - 3y + 20z = 25$. 7

(b) Solve using Runge - Kutta method of order 4: $y' = 8.5 - 20x + 12x^2 - 2x^3$, $y(0) = 1$ for $x = .5$ [Choose $h = .5$] . 7

B24ME2T04	THEORY OF MACHINES	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course provides an in-depth study of kinematic principles, emphasizing the analysis of motion in mechanical systems, including displacement, velocity, and acceleration. It covers the operational theory of cams, gears, gear trains, and mechanism synthesis. Additionally, advanced topics such as static force analysis of planar mechanisms, gyroscopic effect dynamics, and the assessment and correction of unbalance in rotating and reciprocating systems are included to prepare students to tackle complex mechanical challenges effectively.

Prerequisite

Nil

Course Outcomes

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

CO 1	Apply kinematic principles to evaluate various mechanisms and perform displacement and velocity analysis. (Cognitive Knowledge Level: Apply)
CO 2	Apply graphical and analytical methods to calculate acceleration of different mechanisms and synthesize cam profiles for different motion types. (Cognitive Knowledge Level: Apply)
CO 3	Understand the gear terminology, tooth profiles and apply different techniques to synthesize four bar mechanism. (Cognitive Knowledge Level: Apply)
CO 4	Apply static force analysis techniques to different mechanisms and evaluate the effects of gyroscopic couples. (Cognitive Knowledge Level: Apply)
CO 5	Apply different methods to determine the unbalance in rotating and reciprocating masses. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	10	10	10
Understand	30	30	30
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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

KNOWLEDGE IS POWER

SYLLABUS

MODULE 1 (9 hours)

Introduction to kinematics and mechanisms - various mechanisms, kinematic diagrams, degree of freedom- Grashof's criterion, inversions, coupler curves, mechanical advantage, transmission angle. Straight line generation mechanisms – exact & approximate. Velocity analysis of planar mechanisms Instantaneous centre -Kennedy's theorem – relative velocity method.

MODULE 2 (9 hours)

Acceleration analysis- Relative acceleration - Coriolis acceleration - graphical and analytical methods.

Cams - classification of cam and followers - displacement diagrams, velocity and acceleration analysis of SHM, uniform velocity, uniform acceleration. Graphical cam profile synthesis.

MODULE 3 (10 hours)

Gears – Classification- terminology of spur gears – law of gearing -tooth profiles- involute spur gears- contact ratio - interference - backlash - gear standardization –interchangeability. Gear trains - simple and compound gear trains - planetary gear trains.

Kinematic synthesis (planar mechanisms) - type, number and dimensional synthesis - precision points – Freudenstein's equation – path and prescribed timing. Graphical synthesis for motion -– Synthesis of 4 bar mechanisms

Computer Aided Synthesis of mechanisms.

MODULE 4 (8 hours)

Static force analysis- Analysis of four bar linkages and slider crank mechanism, graphical method, Matrix method, principle of virtual work. Analysis of four bar and slider crank mechanisms with sliding and pin friction.

Gyroscopic couples-spin, precession and applied gyroscopic couple vectors-effects on the stability of two wheelers, four wheelers, sea vessels and air crafts, application of gyroscopes

MODULE 5 (9 hours)

Static balancing-dynamic balancing-balancing of several masses in the same plane-several masses in different planes-graphical and analytical method-force and couple polygons.

Balancing of reciprocating masses -Single cylinder engine-multi cylinder engine -V-engine.

Simulation and Analysis of mechanisms using software.

Text Books

1. S. S. Rattan, "Theory of Machines'', Tata Mc Graw Hill, 2019.
2. Ballaney P. L., ''Theory of Machines and Mechanisms'', Khanna Publishers, 2018.

Reference Books

1. C. E. Wilson, P. Sadler, ‘’Kinematics and Dynamics of Machinery’’, Pearson Education,2014.
2. D. H. Myskza, ‘’Machines and Mechanisms Applied Kinematic Analysis’’, Pearson Education, 2015.
3. G. Erdman, G. N. Sandor, ‘’Mechanism Design: Analysis and synthesis’’, Vol I & II, Prentice Hall of India, 2001.
4. Ghosh, A. K. Malik, ‘’Theory of Mechanisms and Machines’’, Affiliated East West Press, 2015.
5. J. E. Shigley, J. J. Uicker, ‘’Theory of Machines and Mechanisms’’, McGraw Hill, 2023.
6. Norton, ‘’Kinematics and Dynamics of Machinery’’, Tata McGraw Hill, 2009.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module1	**9**
1.1	Introduction to kinematics and mechanisms- various mechanisms.	2
1.2	Kinematic diagrams, degree of freedom- Grashof’s criterion.	2
1.3	Inversions.	1
1.4	Coupler curves, mechanical advantage, transmission angle.	1
1.5	Straight line mechanisms exact, approximate.	1
1.6	Velocity analysis- Instantaneous centre -Kennedy’s theorem- Relative velocity	2
	Module 2	**9**
2.1	Acceleration analysis- Relative acceleration, Coriolis acceleration.	1
2.2	Graphical and analytical methods.	2
2.3	Cams - classification of cam and followers.	1
2.4	Displacement diagrams, velocity and acceleration analysis of SHM.	2
2.5	Uniform velocity, uniform acceleration.	1
2.6	Graphical cam profile synthesis.	2
	Module 3	**10**
3.1	Gears – Classification- terminology of spur gears – law of gearing	1
3.2	Tooth profiles- involute spur gears- contact ratio - interference - backlash - gear standardization –interchangeability	1
3.3	Gear trains - simple and compound gear trains - planetary gear trains.	2
3.4	Kinematic synthesis (planar mechanisms) - type, number and dimensional synthesis.	2
3.5	Precision points – Freudenstein's equation -path and prescribed timing.	1

3.6	Graphical synthesis for motion -– Synthesis of 4 bar mechanisms	2
3.7	Computer Aided Synthesis of mechanisms.	1
	Module 4	**8**
4.1	Static force analysis- Analysis of four bar linkages and slider crank mechanism.	2
4.2	Graphical method, Matrix method.	1
4.3	principle of virtual work	1
4.4	Analysis of four bar and slider crank mechanisms with sliding and pin friction.	1
4.5	Gyroscopic couples-spin, precession and applied gyroscopic couple vectors.	2
4.6	Effects on the stability of, Four wheelers, two wheelers- sea vessels and air crafts	1
	Module 5	**9**
5.1	Static balancing-dynamic balancing	2
5.2	Balancing of several masses in the same plane	1
5.3	Several masses in different planes-graphical andmanalytical method	1
5.4	Force and couple polygons	1
5.5	Balancing of reciprocating masses -Single cylinder engine	1
5.6	Multi cylinder engine-v engine-inline engine	2
5.7	Simulation and Analysis of mechanisms using ADAMS software.	1
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. What are the different types of mechanism?
2. Explain the inversions of a four-bar mechanism.
3. What is Grashof's criterion and how it determines the degree of freedom of a mechanism?
4. Explain different classifications of straight-line mechanism.

Course Outcome 2 (CO2):

1. How is relative acceleration analyzed in mechanisms?
2. What is the significance of Coriolis acceleration in the motion of linkages, and how is it analyzed?
3. What are the different types of cams and followers?
4. How can displacement diagrams be used in the analysis of cam motions?

Course Outcome 3 (CO3):

1. What are the different classifications of gears?
2. With a neat sketch explain the terminology of spur gears.
3. What is Freudenstein's equation, and how is it used in the dimensional synthesis of mechanisms?
4. Explain the significance of path and prescribed timing in the synthesis of planar mechanisms.

Course Outcome 4 (CO4):

1. Perform the static force analysis of a slider-crank mechanism under various loading conditions.
2. Explain the principle of virtual work.
3. Explain gyroscopic effect.
4. How does the precession of a gyroscope affect the motion of a vehicle or aircraft?

Course Outcome 5 (CO5):

1. What is the difference between static and dynamic balancing?
2. Determine the magnitude and location of the balancing masses needed to balance the unbalanced masses rotating in different planes.
3. How can reciprocating masses be balanced in a single-cylinder engine?
4. How is dynamic balancing achieved in multi-cylinder and V-engine configurations?

KNOWLEDGE IS POWER

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FOURTH SEMESTER B TECH DEGREE EXAMINATION, JUNE 2025

Course Code: **B24ME2T04**

Course Name: **THEORY OF MACHINES**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What do you mean by degree of freedom? How is it determined?
2. Explain Kennedy's theorem related to the instantaneous centres.
3. How do you find the magnitude and direction of Coriolis component of acceleration?
4. Obtain an expression for maximum velocity when a cam follower motion is in simple harmonic.
5. What do you mean by interference in gears?
6. Write three advantages of involute gear tooth profile over cycloid profile.
7. Explain the principal of virtual work.
8. How does gyroscope help in the guidance of ships?
9. Differentiate between static balancing and dynamic balancing.
10. What do you mean by primary and secondary unbalance in reciprocating engines?

PART B

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

Module 1

11. For a four-bar mechanism ABCD with the following dimensions, calculate the velocity of joint C and the angular velocities of links CD and BC, if the angular velocity of link AB is 10 rad/sec in the clockwise direction. The dimensions are: AB = 30 cm, BC = CD = 35 cm, AD (fixed) = 60 cm, and angle BAD = 60. Solve using the graphical method. (14 marks)

OR

12. a) With a neat sketch explain various inversions of a single slider crank chain. (8 marks)

    b) With the help of a 4-bar mechanism of suitable dimensions of your choice, show the 3 types of instantaneous centres. (6 marks)

Module 2

13. For a slider-crank mechanism, the crank length is 200 mm, and the connecting rod length is 600 mm. The angular velocity of the crank is 50 rad/sec (clockwise), and the angular acceleration is 800 rad/sec² (clockwise). The crank angle is 1.20° from the inner dead center. Find the angular velocity and angular acceleration of the connecting rod. (14 marks)

OR

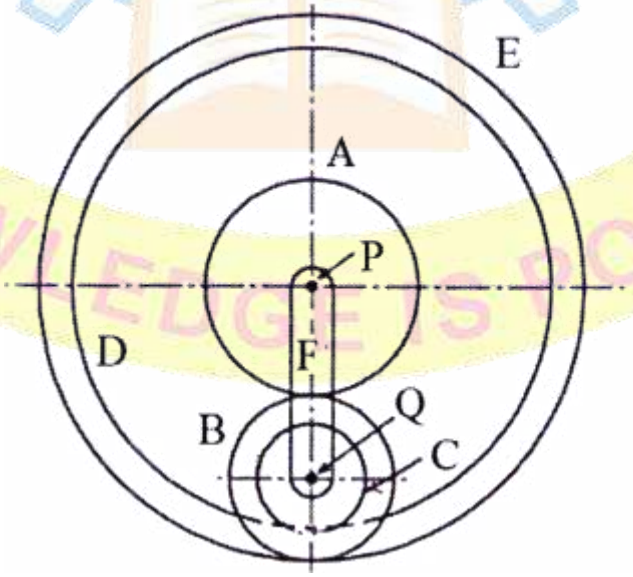
14. A disc cam profile is to be synthesized to provide simple harmonic motion (SHM) to a knife-edge offset follower during the outstroke of 50 mm. The cam's motion consists of the following: an ascent angle of 120°, dwell for 60°, a descent angle of 90°, and the follower dwells for the remaining cam rotation. The minimum radius of the cam is 50 mm. (14 marks)

    a) Draw the cam profile when the knife-edge follower is offset by 20 mm.

    b) Calculate the maximum velocity and acceleration during ascent and descent when the camshaft revolves at 240 rpm, and plot the velocity and acceleration diagrams.

Module 3

15. In a compound epicyclic gear train, as shown in the diagram, gears A, D, and E rotate freely on the axis P. The compound gears B and C rotate together on axis Q at the end of arm F. All gears have equal module, and the number of teeth on gears A, B, and C are 18, 45, and 21, respectively. Gears D and E are annular gears. Gear A rotates at 120 rpm counter-clockwise, and gear D rotates at 450 rpm clockwise. Determine the speed and direction of the arm F and gear E.



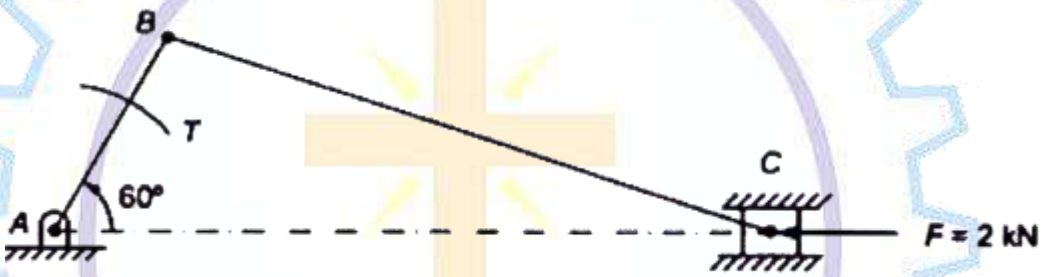
(14 marks)

16. a) What is Freudenstein's equation, and how can it be used to synthesize a four-bar mechanism to coordinate the input and output angles? Explain the process. (8 marks)

    b) Synthesize a slider-crank mechanism with an eccentricity of 9 mm for two input positions of the input link. $\Theta_{12} = 60^0$ and output slider displacement is 16 mm. (6 marks)

Module 4

17. In the slider-crank mechanism shown in figure, where the force applied to the slider is 2 kN, and the link dimensions are as follows: AB = 80 mm, BC = 240 mm, and the crank angle θ=60∘. Determine the forces acting on the various links and the driving torque T.



(14 marks)

OR

18. An airplane flying at 240 km/h turns left and completes a quarter cycle with a radius of 60 m. The mass of the engine and propeller is 450 kg, with a radius of gyration of 320 mm. The engine speed is 2000 rpm in the clockwise direction when viewed from the rear. Calculate the gyroscopic couple acting on the aircraft. (14 marks)

Module 5

19. Four masses m1, m2, m3, and m4 have values of 200 kg, 300 kg, 240 kg, and 260 kg, respectively. The corresponding radii of rotation are 0.2 m, 0.5 m, 0.25 m, and 0.3 m, respectively, with the angles between successive masses being 45°, 75°, and 135°. Determine the position and magnitude of the balancing mass required, assuming its radius of rotation is 0.2 m. (14 marks)

OR

20. An inside-cylinder locomotive has its cylinder centerlines 0.7 m apart and a stroke of 0.6 m. The rotating mass per cylinder is equivalent to 150 kg at the crank pin, and the reciprocating mass per cylinder is 180 kg. The wheel centerlines are 1.5 m apart, and the cranks are at right angles. The entire rotating and half of the reciprocating masses are to be balanced by masses placed at a radius of 0.6 m. Calculate the fluctuation in rail pressure under one wheel, the variation of tractive effort, and the magnitude of the swaying couple at a crank speed of 300 rpm. (14 marks)

B24ME2T05	METROLOGY AND MACHINE TOOLS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	4	3	2024

Preamble

This course provides a comprehensive understanding of machining fundamentals and precision measurement, emphasizing the operation of machine tools and advanced metrology techniques. It equips students with essential skills in manufacturing optimization, quality assurance, and process control. By integrating theoretical knowledge with practical applications, the course prepares students to analyze, measure, and enhance manufacturing processes, ensuring compliance with industry standards and improving overall production efficiency.

Prerequisite

Nil

Course Outcomes

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

CO 1	Apply the principles of machining operations, including cutting forces, chip formation, and tool geometry. (Cognitive Knowledge Level: Apply)
CO 2	Explain the working principles and applications of machine tools such as lathes, shapers, drilling, boring, milling, and grinding machines. (Cognitive Knowledge Level: Understand)
CO 3	Apply advanced techniques for surface finishing, gear cutting, and thread production to achieve precise manufacturing requirements (Cognitive Knowledge Level: Apply)
CO 4	Make use of precision measurement tools to assess limits, fits, tolerances, and dimensional accuracy in manufacturing processes. (Cognitive Knowledge Level: Apply)
CO 5	Apply and utilize advanced metrology tools, including CMM and laser interferometers, to ensure quality control in industrial applications. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	10	10	10
Understand	50	30	30
Apply	40	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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1 (8 hours)

Metal cutting: Theory metal cutting in turning, Tool nomenclature, attributes, surface roughness obtainable- Mechanism of metal removal.
Merchant's theory: Mechanics of machining, Merchant's Circle
Types of chips: Mechanism of chip formation –chip breakers. Continuous, discontinuous, and built-up edge chips.
Orthogonal vs. oblique cutting, tool wear, tool life, machinability.

MODULE 2 (10 hours)

General Purpose Machines: Types and classification of machine tools
Lathe: Types and classification of lathe – methods of holding work and tool –lathe accessories and attachments –lathe operations Lathe operations: Turning, Facing, Knurling, taper turning, threading.
Shaper, slotter, and planner: Principles, operations, Quick return mechanisms and applications.
Broaching Machines: Broaching –different machines – cutter for broaching – broaching processes – internal and external broaching
Drilling and boring machines: Specifications, operations, twist drill geometry, tool holding, boring tools and reamers.

MODULE 3 (8 hours)

Milling machines: Milling machines – types and specifications- Milling operations and types of milling cutters used for each. Milling tool nomenclature - Cutting forces in milling.
Calculation of machining time- Indexing head (Simple and Direct) and its applications.
Grinding machines: types of grinding machines-operations: cylindrical, surface and center less grinding – internal grinding, tool and cutter grinding - grinding mechanisms. Grinding wheels: Specification – types of abrasives, grain size -Types of bond, grade, and structure – Marking system of grinding wheels – Selection of grinding wheels –need of better surface finish.
Finishing processes: Lapping, honing, burnishing, comparison of surface textures.

MODULE 4 (9 hours)

Metrology –principles of achieving accuracy –economic machining accuracy – precision vs accuracy - errors- standards of measurements.
Limits, fits, and tolerances: Theory of tolerances and allowances –system of limits and fits – types of fits – interchangeability and selective assembly; Hole and shaft basis system, GO and NO-GO gauges - types, principle of gauge tolerance –wear allowance-gauge materials.
Linear and angular measurements: Vernier caliper, sine bar, bevel protractor, autocollimator.
Surface roughness: CLA, RMS, Rz values, measurement techniques.

MODULE 5 (10 hours)

Gear measurement: Tooth thickness, pitch errors, methods for gear tooth profile generation.
Screw thread measurement: Screw thread measurement – Screw thread terminology; Measurement of major diameter; Measurement of minor or root diameter. Measurement of pitch; Measurement of effective diameter with two wire method and three wire method.
Advanced devices: CMM, Types of CMM; Advantages and application of CMM. CMM probes, types of probes – contact probes and non-contact probes, laser interferometers, Machine Vision – Introduction to machine vision, functions, applications and advantages of machine vision.

Text Books

1. HMT, Production Technology, A practical approach to machine tools and their industrial applications with illustrations. Tata McGraw Hill.
2. I.C. Gupta, A Textbook of Engineering Metrology, Dhanpat Rai & Co.
3. S.K. Hajra Choudhury, Elements of Workshop Technology Vol. II, Media Promoters & Publishers.
4. P.N. Rao, Manufacturing Technology Vol. II, McGraw Hill Education.
5. S.K. Hajra Choudhury, Workshop Technology Vol. II, Media Promoters & Publishers.

Reference Books

1. Serope Kalpakjian and Steven Schmid, Manufacturing Engineering and Technology, Pearson Education.
2. Raghavendra N.V. and Krishnamurthy L., Engineering Metrology and Measurements, Oxford University Press.
3. R.K. Jain, Precision Engineering: Metrology and Instrumentation, Khanna Publishers.
4. David A. Stephenson and John S. Agapiou, Metal Cutting Theory and Practice, CRC Press.
5. S.F. Scarr, Handbook of Metrology and Measurement Systems, Springer.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module1	**8**
1.1	Introduction to metal cutting in turning	1
1.2	Tool nomenclature: Definitions and attributes	1
1.3	Surface roughness obtainable in machining	1
1.4	Mechanism of metal removal in turning	1
1.5	Merchant's theory: Mechanics of machining and Merchant's Circle	1
1.6	Types of chips: Continuous, discontinuous, and built-up edge chips	1
1.7	Mechanism of chip formation and chip breakers	1
1.8	Orthogonal vs. oblique cutting: Comparison and applications	1
	Module 2	**10**
2.1	Classification and types of general-purpose machine tools	1
2.2	Lathe: Types, classifications, and overview	1
2.3	Methods of work holding and tool holding in lathes	1
2.4	Lathe accessories and attachments Lathe operations: Turning, facing,	1

2.5	Specialized lathe operations: knurling Taper turning and threading	1
2.6	Shaper machines: Principles, operations, and quick return mechanism	1
2.7	Slotter and planner machines: Principles and applications	1
2.8	Broaching machines: Overview of types and classifications	1
2.9	Internal and external broaching processes and tools	1
2.10	Drilling and boring machines: Specifications and operations	1
	Module 3	**8**
3.1	Types and specifications of milling machines	1
3.2	Milling operations and types of milling cutters	1
3.3	Cutting forces in milling and machining time calculation	1
3.4	Indexing head: Simple and direct indexing techniques	1
3.5	Types and operations of grinding machines	1
3.6	Grinding mechanisms: Cylindrical, surface, and centerless grinding	1
3.7	Grinding wheels: Types, specifications, and selection criteria	1
3.8	Overview of finishing processes: Lapping, honing, and burnishing	1
	Module 4	**9**
4.1	Principles of metrology: Accuracy, precision, and standards	1
4.2	Common measurement errors and their impact (Systematic and Random errors only)	1
4.3	Theory of tolerances and allowances in manufacturing	1
4.4	Limits and fits: Hole and shaft basis system	1
4.5	Types of fits: Clearance, interference, and transition fits	1
4.6	Interchangeability and selective assembly in manufacturing	1
4.7	GO and NO-GO gauges: Types, principles, and design	1
4.8	Linear measurement tools: Vernier caliper and micrometer	1
4.9	Angular measurement tools: Sine bar, bevel protractor, and autocollimator	1
	Module 5	**10**
5.1	Gear measurement: Tooth thickness and pitch errors	1
5.2	Gear profile generation and methods to correct errors	1
5.3	Screw thread measurement: Major, minor, and effective diameters	1
5.4	Two-wire and three-wire methods for screw thread measurement	1
5.5	Coordinate Measuring Machine (CMM): Principles and types	1
5.6	CMM applications and advantages in manufacturing	1
5.7	CMM probes: Contact and non-contact probes	1
5.8	Laser interferometers: Working principles and applications	1
5.9	Introduction to machine vision systems: Overview and features	1
5.10	Machine vision: Industrial functions and applications	1
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the mechanics of metal cutting with the help of Merchant's Circle.
2. Differentiate between orthogonal and oblique cutting with suitable examples.
3. Describe the geometry of a single-point cutting tool and its impact on chip formation.
4. Analyze the effect of cutting forces on tool wear and material removal rate.
5. Discuss the types of chips formed in machining and the conditions that promote their formation.

Course Outcome 2 (CO2):

1. Explain the various operations performed on a lathe, including turning, taper turning, and threading.
2. Describe the quick return mechanism used in shaping machines with a neat sketch.
3. Compare and contrast drilling and boring operations in terms of tools, techniques, and applications.
4. Illustrate the indexing methods used in milling operations with examples.
5. Discuss the types of grinding machines and their applications in surface and cylindrical grinding.

Course Outcome 3 (CO3):

1. Describe the lapping and honing processes and their role in achieving precise surface finishes.
2. Explain gear hobbing and gear shaping methods with neat diagrams.
3. What are the major challenges in thread cutting on a lathe, and how can these be overcome using advanced techniques?
4. Discuss the importance of burnishing in surface finishing and compare it with other methods.
5. Illustrate the steps involved in producing helical gears using advanced machining tools.

Course Outcome 4 (CO4):

1. Define limits, fits, and tolerances, and explain their importance in manufacturing processes.
2. With a neat sketch, explain the construction and working of a GO/NO-GO gauge.
3. Describe the procedure for using a sine bar to measure an angle accurately.
4. Differentiate between unilateral and bilateral tolerance systems with examples.
5. Solve a numerical problem to calculate the dimensional tolerances for a given clearance fit.

Course Outcome 5 (CO5):

1. What are Coordinate Measuring Machines (CMM)? Explain their types and applications in modern manufacturing.
2. Discuss the working principle of a laser interferometer and its use in precision measurement.
3. Explain the concept of gear measurement and how CMM can be used to inspect gear profiles.
4. How do advanced metrology tools contribute to quality control in industrial applications? Provide examples.
5. Compare traditional metrology tools with modern ones like CMM in terms of accuracy, speed, and versatility.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FOURTH SEMESTER B TECH DEGREE EXAMINATION, JUNE 2025

Course Code: **B24ME2T05**

Course Name: **METROLOGY AND MACHINE TOOLS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the concept of cutting forces using Merchant's Circle.
2. Differentiate between orthogonal and oblique cutting.
3. What are the advantages of the quick return mechanism in shaping machines?
4. List the key differences between drilling and boring operations.
5. Explain the principle of milling operations.
6. What are the primary differences between lapping and honing?
7. What are the key differences between unilateral and bilateral tolerance systems?
8. Explain the use of slip gauges in linear measurement.
9. What are the different types of Coordinate Measuring Machines (CMM)?
10. Define surface roughness parameters: CLA, RMS, and Rz values

PART B

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

Module 1

11. a) Draw and explain the geometry of a single-point cutting tool. (7 Marks)

    b) Discuss the various types of chips formed in machining and the conditions favoring their formation. (7 Marks)

OR

12. a) Analyze the relationship between cutting speed, feed, and depth of cut with tool life. (7 Marks)

    b) Explain the machinability index and factors affecting machinability. (7 Marks)

Module 2

13. a) Explain the working principle of a shaping machine with a neat sketch. (7 Marks)

    b) Describe the quick return mechanism used in shaping machines. (7 Marks)

OR

14. a) Discuss the tool geometry of a twist drill with a neat diagram. (7 Marks)

    b) Compare and contrast the applications of boring and reaming operations. (7 Marks)

Module 3

15. a) Describe the different types of milling cutters and their applications. (7 Marks)

    b) Explain the direct and simple indexing methods used in milling. (7 Marks)

OR

16. a) Explain the construction and working of cylindrical grinding machines. (7 Marks)

    b) Discuss the specifications of grinding wheels and their importance in selecting the right wheel. (7 Marks)

Module 4

17. a) Define limits, fits, and tolerances, and explain the hole and shaft basis system with examples. (7 Marks)

    b) Explain the working of a GO/NO-GO gauge with a neat diagram. (7 Marks)

OR

18. a) With a diagram, explain the construction and working of an autocollimator. (7 Marks)

    b) The specification of a part is given as 50H7d9. The fundamental deviation for *d* is 80 microns and tolerance grade IT7 and IT9 are 25 and 62 microns respectively. With the help of a figure, explain the geometry of the given part. (7 Marks)

Module 5

19. a) Explain the principle of laser interferometry and its application in precision measurement. (7 Marks)

    b) Discuss the role of CMM in quality control, with examples of components it can inspect. (7 Marks)

OR

20. a) Explain the methods of gear tooth thickness measurement using the constant chord method. (7 Marks)

    b) Compare traditional metrology tools with modern tools like CMM in terms of accuracy and versatility. (7 Marks)

B24ME2T06	ENGINEERING THERMODYNAMICS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

The course on Engineering thermodynamics examines energy, its conversion, and its interaction with matter. This course explores the principles of heat, work, and thermodynamic laws, which are fundamental to designing efficient systems such as engines and power plants. A solid understanding of these concepts is essential for tackling challenges in energy production, consumption, and environmental sustainability.

Prerequisite

Nil

Course Outcomes

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

CO 1	Understand the Zeroth law of Thermodynamics to define temperature and to apply its basic principles to thermal systems (Cognitive Knowledge Level: Apply)
CO 2	Apply first law of thermodynamics to analyse energy interactions and mass balance in flow and non-flow processes. (Cognitive Knowledge Level: Apply)
CO 3	Apply second law to various processes to determine entropy and availability changes (Cognitive Knowledge Level: Apply)
CO 4	Identify change in properties of pure substances during phase change processes (Cognitive Knowledge Level: Apply)
CO 5	Interpret various property relations and experiment with various power generating thermodynamic cycles. (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	1	2		1		1			1
CO 2	3	2	1	2		1		1			1
CO 3	3	2	1	2		1		1			1
CO 4	3	2	1	2		1		1			1
CO 5	3	2	1	2				1			1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	10	10	10
Understand	40	40	40
Apply	50	50	50
Analyse			
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

KNOWLEDGE IS POWER

SYLLABUS

MODULE 1 (8 hours)

Role of Thermodynamics and it's applications in Engineering and Science –Basic Concepts Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic System and Control Volume, Surrounding, Boundaries, Types of Systems, Universe, Thermodynamic properties, Process, Cycle, Thermodynamic Equilibrium, Quasi – static Process, State, Point and Path function. Zeroth Law of Thermodynamics, Measurement of Temperature, reference Points, Temperature Scales.

MODULE 2 (8 hours)

Energy - Work - Pdv work and other types of work transfer, free expansion work, heat and heat capacity. First law of Thermodynamics - First law applied to Non flow Process- Flow work, Enthalpy- specific heats, First law applied to Flow Process, Mass and Energy balance in simple steady flow process. Applications of SFEE, Limitations of the First Law.

MODULE 3 (10 hours)

Second Law of Thermodynamics, Thermal Reservoir, Heat Engine, Heat pump – Kelvin-Planck and Clausius Statements, Equivalence of two statements, Reversibility, Irreversible Process, Causes of Irreversibility, Carnot's theorem and its corollaries, Absolute Thermodynamic Temperature scale. Clausius Inequality, Entropy- Entropy changes in various thermodynamic processes, principle of increase of entropy and its applications, Entropy generation, Entropy and Disorder, Isentropic process, Third law of thermodynamics, Available Energy, Availability and Irreversibility- Second law efficiency.

MODULE 4 (10 hours)

Pure Substances, Phase Transformations, Triple point, properties during change of phase, T-v, p-v and p-T diagram of pure substance, p-v-T surface, Saturation pressure and Temperature, T-h and T-s diagrams, h-s diagrams or Mollier Charts, Dryness Fraction, steam tables. Property calculations using steam tables. The ideal Gas Equation, Characteristic and Universal Gas constants, Deviations from ideal Gas Model: Equation of state of real substances, Vander Waals Equation of State, Compressibility factor, Law of corresponding state, Compressibility charts.

MODULE 5 (9 hours)

General Thermodynamic Relations – Combined First and Second law equations – Helmholtz and Gibb's functions - Maxwell's Relations, Tds Equations. The Clapeyron Equation.

Analysis of Power Generation Cycles- Ideal Rankine Cycle -Effect of Temperature and Pressure on The Rankine Cycle, Ideal Brayton Cycle, Turbine work, Compressor work and Efficiency.

Text Books

1. Yunus Cengel, et al, "Thermodynamics: An Engineering Engineering Approach", McGraw Hill, 9th Edition, 2019

Reference Books

1. Moran J., Shapiro N. M., "Fundamentals of Engineering Thermodynamics", Wiley, 9th Edition, 2018
2. R. E. Sonntag and C. Borgnakke, "Fundamentals of Thermodynamics", Wiley, 8th Edition, 2012
3. P. K. Nag, "Engineering Thermodynamics", McGraw Hill, 6th Edition, 2017

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module1	**8**
1.1	Role of Thermodynamics and it's applications in Engineering and Science	1
1.2	Basic Concepts Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic System and Control Volume, Surrounding, Boundaries, Types of Systems, Universe	2
1.3	Thermodynamic properties, Process, Cycle, Thermodynamic Equilibrium, Quasi-static Process, State, Point and Path function.	2
1.4	Zeroth Law of Thermodynamics, Measurement of Temperature,	1
1.5	Reference Points, Temperature Scales.	2
	Module 2	**8**
2.1	Energy - Work - Pdv work and other types of work transfer, free expansion work,	2
2.2	Heat and heat capacity. First law of Thermodynamics - First law applied to Non flow Process	2
2.3	Flow work, Enthalpy- specific heats, First law applied to Flow Process	1
2.4	Mass and Energy balance in simple steady flow process.	1
2.5	Applications of SFEE, Limitations of the First Law	2
	Module 3	**10**
3.1	Second Law of Thermodynamics, Thermal Reservoir, Heat Engine, Heat pump – Kelvin-Planck and Clausius Statements	1
3.2	Equivalence of two statements, Reversibility, Irreversible Process, Causes of Irreversibility	2
3.3	Carnot's theorem and its corollaries	1
3.4	Absolute Thermodynamic Temperature scale.	1
3.5	Clausius Inequality, Entropy- Entropy changes in various thermodynamic processes, principle of increase of entropy and its applications	2
3.6	Entropy generation, Entropy and Disorder, Isentropic process, Third law of thermodynamics	2

3.7	Available Energy, Availability and Irreversibility- Second law efficiency.	1
	Module 4	**10**
4.1	Pure Substances, Phase Transformations, Triple point, properties during change of phase	2
4.2	T-v, p-v and p-T diagram of pure substance, p-v-T surface, Saturation pressure and Temperature	1
4.3	T-h and T-s diagrams, h-s diagrams or Mollier Charts, Dryness Fraction, steam tables. Property calculations using steam tables.	2
4.4	The ideal Gas Equation, Characteristic and Universal Gas constants,	1
4.5	Deviations from ideal Gas Model: Equation of state of real substances, Vander Waals Equation of State,	2
4.6	Compressibility factor, Law of corresponding state, Compressibility charts	2
	Module 5	**9**
5.1	General Thermodynamic Relations – Combined First and Second law equations	1
5.2	Helmholtz and Gibb's functions - Maxwell's Relations	1
5.3	Tds Equations. The Clapeyron Equation	2
5.4	Analysis of Power Generation Cycles- Ideal Rankine Cycle	2
5.5	Effect of Temperature and Pressure on The Rankine Cycle	2
5.6	Ideal Brayton Cycle, Turbine work, Compressor work and Efficiency.	1
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Discuss the different types of systems.
2. Differentiate between Intensive and extensive properties
3. Explain various temperature scales used in engineering

Course Outcome 2 (CO2):

1. A mass of 2.4 kg of air at 150 kPa and 12°C is contained in a gas – tight, frictionless piston –cylinder device. The air is now compressed to a final pressure of 600 kPa . During this process, heat is transferred from the air such that the temperature inside the cylinder remains constant. Calculate the work input during this process.
2. Carbon dioxide enters an adiabatic nozzle steadily at 1 MPa and 500°C with a mass flow rate of 600 kg/hr and leaves at 100 kPa and 450 m/s. The inlet area of the nozzle is 40 cm2. Determine (a)the inlet velocity and (b) the exit temperature
3. A vertical piston – cylinder device initially contains 0.25 m^3 of air at 600kPa and 300°C. A valve connected to the cylinder is now opened and air is allowed to escape until three-

quarters of the mass leave the cylinder at which point the volume is 0.05 m^3. Determine the final temperature in the cylinder and the boundary work during this process.

Course Outcome 3 (CO3):

1. An adiabatic vessel contains 2 kg of water at 25℃. By paddle – wheel work transfer, the temperature of water is increased to 30℃. If the specific heat of water is assumed to be constant at 4.186 kJ/kg.K, find the entropy change of the universe.
2. Two kilograms of water at 80°C is mixed adiabatically with 3 kg of water at 30°C in a constant pressure process at 1 atm. Find the increase in entropy of the total mass of water due to the mixing process.
3. Argon enters an insulated turbine operating under steady state at 1000℃ and 2 MPa and exhausts at 350 kPa. The mass flow rate is 0.5 kg/s and the turbine develops power at the rate of 120 kW. Determine (a) the temperature of the argon at the turbine exit, (b) the irreversibility of the turbine and (c) the second law efficiency. Take T_o = 20 ℃ and P_o = 1 bar

Course Outcome 4 (CO4):

1. What are the limitations of ideal gas equation and how does Van der Waals equation overcome these limitations?
2. Discuss law of corresponding states and its role in the construction of compressibility chart.
3. A rigid tank contains 2 kmol of N_2 and 6 kmol of CH_4 gases at 200 K and 12 MPa. Estimate the volume of the tank, using (a) ideal gas equation of state (b) the compressibility chart.

Course Outcome 5 (CO5):

1. Plot the T-s diagram of Rankine Cycle. Explain the processes using a schematic.
2. Derive the efficiency of a Brayton cycle.
3. A gas-turbine power plant operating on an ideal Brayton cycle has a pressure ratio of 8. The gas temperature is 300 K at the compressor inlet and 1300 K at the turbine inlet. Using the air-standard assumptions, determine (a) the gas temperature at the exits of the compressor and the turbine, (b) the back work ratio, and (c) the thermal efficiency.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg.No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FOURTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: **B24ME2T06**

Course Name: **ENGINEERING THERMODYNAMICS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define thermodynamics. List a few of its applications
2. Differentiate between intensive and extensive properties.
3. Differentiate between heat and work.
4. State the first law of thermodynamics for a closed system.
5. Define internal energy and enthalpy.
6. Explain system approach and control volume approach as applied in the analysis of a flow process.
7. An inventor claims to have developed an engine that delivers 26 kJ of work using 82 kJ of heat while operating between temperatures 120°C and 30°C. Is his claim valid? Give the reason for your answer.
8. Define (i) critical point and (ii) triple point, with respect to water.
9. How can you estimate the pump work in Rankine cycle?
10. Derive the efficiency of a Brayton cycle.

PART B

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

Module 1

11. a) What is meant by thermodynamic equilibrium? What are the essential conditions for a system to be in thermodynamic equilibrium? (7 marks)

    b) Express the temperature of 91^{o}C in (i) Fahrenheit (ii) Kelvin (iii) Rankine. (7 marks)

OR

12. a) Explain macroscopic and microscopic approach to thermodynamics. (7 marks)

    b) With the aid of a suitable diagram, explain the working of constant volume gas thermometer. (7 marks)

Module 2

13. a) A mass of 2.4 kg of air at 150 kPa and 12°C is contained in a gas – tight, frictionless piston –cylinder device. The air is now compressed to a final pressure of 600 kPa. During this process, heat is transferred from the air such that the temperature inside the cylinder remains constant. Calculate the work input during this process. (7 marks)

    b) A 2 m^3 rigid tank initially contains air at 100 kPa and 22°C. The tank is connected to a supply line through a valve. Air is flowing in the supply line at 600 kPa and 22°C. The valve is opened, and air is allowed to enter the tank until the pressure in the tank reaches the line pressure, at which point the valve is closed. A thermometer placed in the tank indicates that the air temperature at the final state is 77°C. Determine, (i) the mass of air that has entered the tank and (ii) the amount of heat transfer. (7 marks)

OR

14. a) A turbine operates under steady flow conditions, receiving steam at the following conditions: pressure 1.2 MPa, temperature 188°C, enthalpy 2785 kJ/kg, velocity 33.3 m/s and elevation 3m. The steam leaves the turbine at the following conditions: pressure 20 kPa, enthalpy 25kJ/kg, velocity 100 m/s, and elevation 0 m. Heat is lost to the surroundings at the rate of 0.29 kJ/s. If the rate of steam flow through the turbine is 0.42kg/s, what is the power output of the turbine in kW? (7 marks)

    b) State the general energy balance equation for an unsteady flow system and from it, derive the energy balance equation for a bottle filling process, stating all assumptions. (7 marks)

Module 3

15. a) State the Kelvin-Planck and Clausisus statements of the second law of thermodynamics and prove their equivalence. (7 marks)

    b) A heat engine operating between two reservoirs at 1000 K and 300 K is used to drive a heat pump which extracts heat from the reservoir at 300 K at a rate twice that at which the engine rejects heat to it. If the efficiency of the engine is 40 % of the maximum possible and the COP of the heat pump is 50% of the maximum possible, what is the temperature of the reservoir to which the heat pump rejects heat? What is the rate of heat rejection from the heat pump, if the rate of heat supply to the engine is 50 kW? (7 marks)

OR

16. A house is to be maintained at 21°C during winter and at 26°C during summer. Heat leakage through the walls, windows and roof is about 3000 kJ/hr per degree temperature difference between the interior of the house and the environment. A reversible heat pump is proposed for realising the desired heating and cooling. What is the minimum power required to run the heat pump in the reverse, if the outside temperature during summer is 36°C? Also find the lowest environment temperature during winter for which the inside of the house can be maintained at 21°C consuming the same power.

    (14marks)

Module 4

17. a) Show the constant pressure transformation of unit mass of ice at atmospheric pressure and -20^{o}C to superheated steam at 220^{o}C on P-v , T-v and P-T coordinate systems and explain their salient features. (7 marks)

    b) A rigid vessel of volume 0.3 m^3 contains 10 kg of oxygen at 300 K. Using (i) the perfect gas equation and (ii) the Van der Waal's equation of state, determine the pressure of oxygen in the vessel. Take the Van der Waal's constants for oxygen as a =0.1382 m^6 Pa/ mol^2 and b=0.03186 m^3/ kmol . (7 marks)

OR

18. a) Steam at 25 bar and 300^{o}C expands isentropically to 5 bar. Calculate the change in enthalpy, volume and temperature of unit mass of steam during this process using steam tables and Mollier chart and compare the values. (7 marks)

19. b) Explain law of corresponding states and its significance to the generalized compressibility chart. (7 marks)

Module 5

20. Steam at a pressure of 15 bar and 250^{o}C is expanded through a turbine to a pressure of 4 bar. It is then reheated at constant pressure to initial temperature of 250^{o}C and finally expanded to condenser pressure of 0.1 bar. Calculate efficiency of the cycle. What will be the efficiency if reheating is not employed? Pump work can be neglected. (14 marks)

OR

21. Derive the Maxwell's equations. (14 marks)

KNOWLEDGE IS POWER

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.

Prerequisite: Nil

Course outcomes: After the completion of the course the students will be able to:

CO 1	Understand the fundamental concepts and theories of demand, supply, and production to various related economic issues. **(Cognitive Knowledge Level: Understand)**
CO 2	Understand the concepts relating to costs and revenue to the functioning of firms in different market situations and solve simple business problems using break even analysis. **(Cognitive Knowledge Level: Understand)**
CO 3	Apply the basic macroeconomic principles to economic concepts influencing 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	Make use of the possibilities 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	Develop decision making capability by acquiring knowledge in stock markets, mutual funds, business financing and international financing. **(Cognitive Knowledge Level: Apply)**

Mapping of course outcomes with program outcomes

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

Assessment Pattern

	Business Economics and Financial Management		
Bloom's Category	**Continuous Assessment Tests**		**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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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.

KNOWLEDGE IS POWER

SYLLABUS

Module 1
Fundamentals of Business Economics (8 Hours)

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
Cost, Revenue and Markets (7 Hours)

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
National Income, Inflation and International Trade (7 Hours))

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
Fundamentals of Financial Management (7 hours)

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
Business Financing (7 hours)

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 Leaning India, 2022.
3. Prasanna Chandra, "Financial Management", McGraw Hill, 2022

Reference Books

1. Paul A Samuelson, "Economics", McGraw Hill, 2019.
2. A. Koutsoyiannis, "Modern microeconomics", Palgrave McMillan, 1979.
3. Geetika Piyali Ghosh and Chodhury "Managerial Economics", McGraw Hill, 2017.
4. M Y Khan & P K Jain, "Financial Management", McGraw Hill, 2018.
5. Ruddar Datt, Indian Economy", S.Chand and Company Ltd, 2018.
6. Dwivedi D N, "Macro Economics", McGraw Hill, 2018.
7. Gregory N Mankiw, "Principles of Micro Economics", Cengage Leaning India, 2020
8. James C Van Horne, "Financial Management and Policy", Pearson Education, 20

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture /Tutorial hours
1	**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.		
2	**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 - Shutdown 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.*		
3	**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.*		
4	**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.*		
5	**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.*		
	Total	**36 hours**

* Activities are a desirable part of the course.

CO ASSESSMENT QUESTIONS

Course Outcome 1 CO1):

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 (CO2):

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 (CO3):

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 (CO4):

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 (CO5):

1. Elucidate the main problems faced by the stock market in India.
2. Clarify the significance of mutual funds? Mention the main types of mutual funds.
3. Distinguish between FDI and FII.

Model Question Paper

QP CODE: Pages: 3

Reg No.:_____

Name:_____

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

THIRD SEMESTER B. TECH DEGREE EXAMINATION, DECEMBER 2025

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.

MODULE 1

11a. 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 (7 Marks)

is combined with 196 units of capital

OR

12a. 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)

MODULE 2

13a. 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 firms fixed expenses are Rs.15,00,000. Find the breakeven quantity of the firm. (7 Marks)

OR

14a. 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)

MODULE 3

15a. 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

16a. Elucidate the economic problem of inflation. What are its main types? (7 Marks)

State the government measures to control inflation.

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)

MODULE 4

17a. 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

18a. 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)

MODULE 5

19a. 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

20a. Elaborate the meaning of mutual funds. Discuss the different types of mutual funds (7 Marks)

b. Distinguish between FDI and FII. (7 Marks)

KNOWLEDGE IS POWER

B24ME2T07	FLUID MACHINES	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course is designed to equip students with a comprehensive understanding of machines that operate using fluids, including pumps, turbines, compressors, and hydraulic systems. Through this course, students will develop the ability to apply their understanding of fluid machines to real-world engineering scenarios. By exploring various applications in industries such as power generation, transportation, and manufacturing, they will gain the confidence to solve complex engineering problems, optimize system performance, and contribute to advancements in fluid-based technologies.

Prerequisite

Nil

Course Outcomes

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

CO 1	Apply knowledge to calculate forces and work done by a jet and to explain turbine working while selecting an appropriate turbine for specific applications. (Cognitive Knowledge Level: Apply)
CO 2	Understand the working of an axial flow turbine and the relevance of a draft tube. (Cognitive Knowledge Level: Understand)
CO 3	Understand the characteristics of rotodynamic pumps and evaluate their performance. (Cognitive Knowledge Level: Understand)
CO 4	Apply fluid mechanics principles to analyze and select positive displacement pumps and related devices for efficient operation in engineering systems. (Cognitive Knowledge Level: Apply)
CO 5	Apply principles of thermodynamics and fluid mechanics to analyze the performance, efficiency, and operation of various compressors and their components in engineering applications. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	10	10	10
Understand	50	30	30
Apply	40	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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

KNOWLEDGE IS POWER

SYLLABUS

MODULE 1 (8 hours)

Impact of jets: Introduction to the hydrodynamic thrust of jet on a fixed and moving surface (flat and curve), Series of vanes, work done and efficiency.
Hydraulic Turbines: Classification of Turbines, Applications, Impulse and Reaction Turbines. Pelton Wheel: Constructional features, Velocity triangles, Euler's equation, Speed ratio, jet ratio and work done, losses and efficiencies, design of Pelton wheel.
Inward and outward flow reaction turbines: Francis Turbine, Degree of reaction, Constructional features, Velocity triangles, work done and efficiencies.

MODULE 2 (6 hours)

Axial flow turbine (Kaplan): Constructional features, Velocity triangles, work done and efficiencies; theory of draft tubes; surge tanks; Cavitation in turbines; Governing of turbines; Specific speed of turbine; Type Number; Scale Laws; unit speed, unit discharge and unit power.

MODULE 3 (7 hours)

Rotodynamic pumps: Centrifugal pump impeller types, velocity triangles, manometric head, work, efficiency and losses, Cavitation in centrifugal pumps; Maximum suction lift, NPSH required and available; Type number; Pumps in series and parallel operations; Performance characteristics; Specific speed.

MODULE 4 (7 hours)

Positive displacement pumps: Reciprocating pump; Single acting and double acting; slip, negative slip, and work required and efficiency indicator diagram, acceleration head, effect of acceleration and friction on indicator diagram, speed calculation.
Air vessels and their purposes, saving in work done to air vessels multi cylinder pumps; Multistage pumps; selection of pumps; pumping devices; Jet pumps; gear pumps; vane pump and lobe pump.

MODULE 5 (8 hours)

Compressors: classification of compressors; Reciprocating compressor- single stage compressor, equation for work with and without clearance volume, efficiencies, multistage compressor, intercooler, free air delivery (FAD).
Centrifugal compressor-working; surging and chocking; Axial flow compressors: - working; Roots blower, vane compressor, screw compressor.

Text Books

1. S. K. Som, Gautam Biswas, S. Chakraborty, Introduction to Fluid Mechanics and Fluid Machines, McGraw Hill, 3rd ed., 2017.
2. Bansal R. K. A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications, 9th ed., 2019.
3. Rajput R. K, Textbook of Fluid Mechanics and Hydraulic Machines, S. Chand, 6th ed., 2016.

Reference Books

1. Yunus A. Cengel and John. M. Cimbala, Fluid Mechanics: Fundamentals and Applications, McGraw Hill, 4th ed., 2019.
2. Yahya S. M, Turbines, Compressors and Fans, McGraw Hill, 4th ed., 2017.
3. Subramanya K., Fluid Mechanics and Hydraulic Machines – Problems and Solutions, McGraw Hill, 2nd ed., 2018.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module1	**8**
1.1	Impact of jets: Introduction to hydrodynamic thrust of jet on a fixed and moving surface (flat and curve), Series of vanes, work done and efficiency.	3
1.2	Hydraulic Turbines: Classification of Turbines, Applications, Impulse and Reaction Turbines.	1
1.3	Pelton Wheel: Constructional features, Velocity triangles, Euler's equation, Speed ratio, jet ratio and work done, losses and efficiencies, design of Pelton wheel.	2
1.4	Inward and outward flow reaction turbines: Francis Turbine, Degree of reaction, Constructional features, Velocity triangles, work done and efficiencies.	2
	Module 2	**6**
2.1	Axial flow turbine (Kaplan): Constructional features, Velocity triangles, work done and efficiencies	2
2.2	Theory of draft tubes	1
2.3	Surge tanks; Cavitation in turbines; Governing of turbines	1
2.4	Specific speed of turbine; Type Number; Scale Laws	1
2.5	Unit speed, unit discharge and unit power	1
	Module 3	**7**
3.1	Rotodynamic pumps: Centrifugal pump, impeller types, velocity triangles, manometric head	2
3.2	Work, efficiency and losses	2
3.3	Cavitation in centrifugal pumps; Maximum suction lift, NPSH required and available	2
3.4	Type number; Pumps in series and parallel operations; Performance characteristics, Specific speed	1
	Module 4	**7**
4.1	Positive displacement pumps: Reciprocating pump; Single acting and double acting; slip, negative slip, and work required and efficiency indicator diagram	2
4.2	Acceleration head, effect of acceleration and friction on indicator diagram, speed calculation	2
4.3	Air vessels and their purposes, saving in work done to air vessels multi cylinder pumps	1
4.4	Multistage pumps; selection of pumps; pumping devices	1
4.5	Jet pumps; gear pumps; vane pump and lobe pump	1

	Module 5	**8**
5.1	Compressors: classification of compressors; Reciprocating compressor: single stage compressor	1
5.2	Equation for work with and without clearance volume	2
5.3	Efficiencies, multistage compressor, intercooler, free air delivered (FAD).	2
5.4	Centrifugal compressor-working	1
5.5	Surging and choking	1
5.6	Axial flow compressors: - working; Roots blower, vane compressor, screw compressor	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Prove that the force exerted by a jet of water on a fixed semi-circular plate in the direction of the jet when the jet strikes at the centre of the semi-circular plate is two times the force exerted by the jet on a fixed vertical plate.
2. A jet of water moving at 60 m/s is deflected by a vane moving at 25 m/s in a direction at 30 degrees to the direction of the jet. The water jet leaves the blade normally to the motion of the vanes. Draw the inlet and outlet velocity triangles and find the vane angles for no shock at entry or exit. Take the relative velocity at the outlet to be 0.85 of the relative velocity at the inlet.
3. Explain the purpose of providing scroll casing and guide vanes for a reaction turbine.
4. In a Pelton wheel turbine, the runner of the turbine is provided with double hemi spherical cup shaped buckets instead of a single curved blade. why?
5. The penstock supplies water from a reservoir to the Pelton wheel with a gross head of 400 m. One-third of the gross head is lost due to friction in the penstock. The rate of flow of water through the nozzle fitted at the end of the penstock is 3.0 m3/s and the angle of deflection of the jet is 160 degrees. Determine the power given by water to the runner and the hydraulic efficiency of the Pelton wheel. The speed ratio = 0.48 and Cv = 0.98.

Course Outcome 2 (CO2):

1. What is meant by the specific speed of a turbine? What is its significance?
2. Explain the purpose and working principle of a surge tank in a hydraulic system.
3. Explain the theory of the draft tube in the reaction turbine. How is the turbine performance affected in the absence of draft tube?
4. A Kaplan turbine is designed to develop 9MW power while operating under a net head of 7m. The speed ratio based on outer diameter and flow ratios are to be 2.09 and 0.68 respectively and the ratio of outer to hub diameter is 3. Assuming an overall efficiency of 85%, find the speed and specific speed of the turbine.

Course Outcome 3 (CO3):

1. A centrifugal pump lifts 2.5 m^3/min of water to a height of 20m through a pipeline of 10 cm diameter. The total length of the pipeline is 11 0m. Assuming an overall efficiency of 75% and an inlet loss of 0.3m, find the power required to drive the pump. Take coefficient of friction f = 0.012
2. What is meant by cavitation in a centrifugal pump? What are the effects of cavitation? How it can be eliminated
3. Define the minimum starting speed of a centrifugal pump. Write down the equation for the same with notations.
4. What is meant by the manometric head of a centrifugal pump? What are the different ways of finding it?

Course Outcome 4 (CO4):

1. The bore and stroke of a double-acting reciprocating pump are 15cm and 30cm respectively. The suction and delivery heads are 3m and 30m and the pump delivers 0.62m3/min when running at 60rpm. Find the percentage slip and power required to run the pump if mechanical efficiency is 80%.
2. With the help of the necessary sketch, explain the working of a jet pump. Where are they used?
3. Show that the saving in work done against friction in a double-acting reciprocating pump fitted with an air vessel is 39.2%
4. Reciprocating pumps are called positive displacement pumps why?

Course Outcome 5 (CO5):

1. Draw the indicator diagram of a single-acting reciprocating compressor with clearance volume and explain the working. Also, derive the expression for work done in terms of pressure ratio and effective swept volume.
2. A double-acting single-stage reciprocating compressor delivers air at the rate of 15 m^3/min. (1 bar, 15 ^{0}C). The suction pressure and temperature in the cylinder are 1 bar and 32 Degree Celsius. The delivery pressure is 7 bar and the compression and expansion index is 1.3. The clearance volume is 5% of the swept volume. Calculate indicated power and volumetric efficiency.
3. Write short notes on (i) FAD (ii) isothermal efficiency (iii) intercooler (iv) clearance ratio in connection with a reciprocating compressor.
4. With a neat sketch elaborate on the working of a centrifugal compressor
5. Explain the working of (i) vane compressor and (ii) screw compressor

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FOURTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: **B24ME2T07**

Course Name: **FLUID MACHINES**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Show that the force exerted by a jet of water on an inclined fixed plate in the direction of the jet is given by: $F_x=\rho AV^2Sin^2\alpha$.
2. Explain the purpose of providing scroll casing and guide vanes for a reaction turbine.
3. Explain the working of a draft tube in an axial reaction turbine with a neat sketch. What is the reason for the absence of a draft tube in an impulse turbine?
4. Define the specific speed of a turbine and derive the expression for it. Explain the significance of specific speed in the selection of a turbine.
5. What is the priming of a centrifugal pump? Explain clearly why priming is essential before starting a centrifugal pump.
6. Explain the terms manometric efficiency, mechanical efficiency and overall efficiency as applied to centrifugal pumps.
7. Define slip, percentage slip and negative slip of a reciprocating pump
8. Explain in brief how and when separation of flow takes place in a reciprocating pump.
9. Explain 'Surging' in centrifugal compressor
10. Compare axial flow compressor with centrifugal flow compressor.

PART B

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

Module 1

11. a) Show that for a series of curved radial vanes, the work done by the jet per second is given by: $\rho aV1[V_{W1}\ u1 \pm V_{W2}\ u2]$ (7 marks)

    b) A free jet of water of area A and velocity V strikes a vertical plate normally. The plate is moving with a velocity u in the direction of the jet. Obtain the value of the ratio

u/V for maximum efficiency of this power transmission system. What is the value of corresponding maximum efficiency? (7 marks)

OR

12. a) A jet of water having a velocity of 40 m/s strikes a curved vane, which is moving with a velocity of 20 m/s. The jet makes an angle of 30^0 with the direction of motion of the vane at the inlet and leaves at an angle of 90^0 with the direction of motion of the vane at the outlet. Draw the velocity triangles at the inlet and outlet and determine the vane angles at the inlet and outlet so that the water enters and leaves the vane without shock. (7 marks)

    b) Prove that the work done per second per unit weight of water in a reaction turbine is given by $1/g\ (V_{w1}\ u1 \pm V_{w2}\ u2)$. (7 marks)

Module 2

13. a) What is the purpose of surge tank and explain its types (7 marks)

    b) What is a draft tube? Explain its functions and draw simple sketches of any two types of draft tubes. (7 marks)

OR

14. a) Define the specific speed of a turbine. Derive an expression for it. (5 marks)

    b) An inward flow reaction turbine has external and internal diameters of 1.0 m and 0.6 m respectively. The hydraulic efficiency of the turbine is 90 % when the head on the turbine is 36 m. The velocity of flow at the outlet is 2.5 m/s and discharge at the outlet is radial. If the vane angle at the outlet is 15 degrees and the width of the wheel is 100 mm at the inlet and outlet, determine: (i) The guide blade angle (ii) the Speed of the turbine (iii) the Vane angle of the runner at inlet (iv) Volume flow rate of the turbine (v) Power developed. (9 marks)

Module 3

15. a) A centrifugal pump lifts 2.5 m3/min of water to a height of 20m through a pipeline of 10cm diameter. The total length of the pipeline is 110 m. Assuming an overall efficiency of 75% and an inlet loss of 0.3 m, find the power required to drive the pump. Take the coefficient of friction f = 0.012. (9 marks)

    b) What is meant by cavitation in a centrifugal pump? What are the effects of cavitation? How it can be eliminated. (5 marks)

OR

16. a) Define the minimum starting speed of a centrifugal pump. Write down the equation for the same with notations. (7 marks)

    b) What is meant by the manometric head of a centrifugal pump? What are the different ways of finding it? (7 marks)

Module 4

17. a) Show that the saving in work done against friction in a double-acting reciprocating pump fitted with an air vessel is 39.2%. (7 marks)

    b) With the help of the necessary sketch, explain the working of a jet pump. Where are they used? (7 marks)

OR

18. The bore and stroke of a double-acting reciprocating pump are 15cm and 30cm respectively. The suction and delivery heads are 3m and 30m and the pump delivers $0.62m^3$/min when running at 60rpm. Find the percentage slip and power required to run the pump if mechanical efficiency is 80%. (14 marks)

Module 5

19. a) Deduce an equation for the work done on a reciprocating compressor in terms of pressure ratio using a P-V diagram. Assume the process of compression follows polytropic according to pv^n = a constant. (7 marks)

    b) A single-stage single-acting reciprocating air compressor is used to compress $7x10^{-3}$ m^3/min of air from a pressure of 1.013 bar to 14 bar. The index of polytropic compression is 1.3 and mechanical efficiency is 82%. Determine the volumetric efficiency and power required to drive the compressor if the clearance is 3% of the swept volume. (7 marks)

OR

20. a) Obtain the expressions for volumetric efficiency of an air Compressor in terms of clearance ratio, index of compression and pressure ratio. (7 marks)

    b) Prove that for a multi-stage compressor with perfect intercooling between stages, the work done is minimal when the intermediate pressure is the geometric mean of the suction and delivery pressure between successive stages. (7 marks)

KNOWLEDGE IS POWER

B24ME2L04	MECHANICAL MEASUREMENTS LAB	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

This course is designed to equip students with a comprehensive understanding of advanced measurement techniques and metrology principles, emphasizing precision and quality assurance in manufacturing processes. Students will gain hands-on experience with modern instruments and methods essential for industrial applications. This course integrates classical and contemporary approaches to dimensional, geometric, and surface measurement, aligning with the evolving needs of industries focused on automation, quality control, and advanced manufacturing technologies. By bridging theoretical concepts with practical experiments, this course ensures readiness for roles in modern industrial environments, including sectors like automotive, aerospace, and precision engineering.

Prerequisite

Nil

Course Outcomes

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

CO 1	Apply precision measurement techniques to evaluate linear dimensions, angles, surface roughness, and bore profiles using advanced metrological tools such as profilometers, optical instruments, and slip gauges. (Cognitive Knowledge Level: Apply)
CO 2	Analyze geometric errors, including straightness, flatness, roundness, and squareness, using state-of-the-art instruments like auto-collimators and surface plates to ensure product quality. (Cognitive Knowledge Level: Analyze)
CO 3	Build proficiency in screw thread and gear parameter measurement using toolmaker's microscopes, comparators, and profile projectors, critical for gear and thread manufacturing industries. (Cognitive Knowledge Level: Apply)
CO 4	Apply skills in industrial instrumentation and automation by conducting experiments in strain gauge load measurement and tachometry preparing for roles in advanced manufacturing setups. (Cognitive Knowledge Level: Apply)
CO 5	Analyze and interpret manufacturing tolerances and surface finish requirements, ensuring compliance with industrial standards for high-precision components in modern engineering applications. (Cognitive Knowledge Level: Analyze)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	3	2		3	3						2
CO 2	3	3		3	3						2
CO 3	3	2		3	3						1
CO 4	3	2	3	3	3				1	2	2
CO 5	3	3	2	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 Evaluation
- Class work/ Assessment : 10 marks
- Viva (Self Study) : 10 marks

Viva voce / test : 15 marks
Record : 5 marks

End Semester Examination Pattern

Experiment part : 70 marks
Viva voce : 30 marks

Guidelines for award of marks for the experiment part:

Preliminary work : 15Marks
Implementing the work/Conducting the experiment : 25 Marks
Performance, result and inference : 30 Marks

KNOWLEDGE IS POWER

SYLLABUS

LIST OF EXPERIMENTS

Minimum **10** experiments are mandatory (Including study)

1	**Experiments on Repeatability and Reproducibility** Study and analysis of repeatability and reproducibility of given batch of steel balls. etc.
2	**Linear measurements** Study of different linear measuring instruments etc. Calibration of LVDT using slip gauges
3	**Straightness error measurement** To check straightness error of a straight edge by the wedge method using slip gauges. Measurement of straightness error of a CI surface plate using auto collimator and comparing
4	**Out of roundness measurement** Measurement of out of roundness using V-block and dial gauge
5	**Screw thread measurement** Measurement of screw thread parameters using two wire and three wire method.
6	**Bore measurement** Measurement of a bore by three ball method.
7	**Gear Metrology** Study of types of gears – gear terminology; gear errors - Profile Projector. Measurement of profile error and gear parameters using profile projector etc.
8	**Use of Tool maker's microscope** Study of tool maker's microscope – use at shop floor applications. Measurement of different angles of single point cutting tool using tool maker's microscope.
9	**Surface roughness measurement** Measurement of surface roughness using surface profilometer /roughness measuring machine of turned, milled, grounded, lapped and glass etc specimens.
10	**Rotation measurement** Determination of rpm using tachometer, optical tachometer and stroboscope, etc.
11	**Strain Gauges Measurement** Load Measurement using Strain Gauges
12	**Angular Measurement** Measurement of Angle using Sine Bar
13	**Gauge Design** Determine the size of GO and NO- GO gauge using Slip Gauges
14	**Squareness measurement** Determination of squareness of a tri-square using angle plate and slip gauges etc.

Reference Books

1. Raghavendra, N.V., Krishnamurthy, L.; Engineering Metrology and Measurements; Oxford University Press, 2013Bansal R.K, Fluid Mechanics and Hydraulic Machines (SI Units); Laxmi Publications, 2011.
2. Galyer, J.F.W., Shotbolt, C.R.; Metrology for Engineers; ELBS, London, 1990Graebel. W. P, "Engineering Fluid Mechanics", Taylor & Francis, Indian Reprint, 2011
3. Dotson, Connie; Fundamentals of Dimensional Metrology; Cengage Learning, 2015
4. Beckwith, T.G., Marangoni, R.D., Lienhard, J.H.; Mechanical Measurements; Pearson Education, 2007
5. Pandey, P.C., Shan, H.S.; Modern Machining Processes; Tata McGraw Hill, 2000
6. Jain, V.K.; Precision Engineering: A Practical Guide to Dimensional Accuracy; CRC Press, 2001
7. Doebelin, Ernest O., Manik, Dhanesh N.; Measurement Systems: Application and Design; McGraw Hill, 2011
8. Bewoor, Anand K., Kulkarni, Vinay A.; Metrology and Measurement Systems; Tata McGraw Hill, 2009

KNOWLEDGE IS POWER

B24ME2L05	FLUID MECHANICS AND MACHINES LAB	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

The fluid mechanics and machines laboratory provides students with practical experience in understanding the behavior of fluids and the operation of fluid machinery. It focuses on key principles of fluid statics, fluid dynamics, and the performance of various fluid machines such as pumps and turbines.

Prerequisite

Nil.

Course Outcomes

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

CO 1	Calibrate flow measuring devices, such as venturimeter, orifice meter, and notches. (Cognitive Knowledge Level: Apply)
CO 2	Apply experimental methods to assess the performance of Pelton, Kaplan, and Francis turbines. (Cognitive Knowledge Level: Apply)
CO 3	Apply performance evaluation tests on hydraulic pumps, including centrifugal, reciprocating, self-priming, and gear pumps. (Cognitive Knowledge Level: Apply)
CO 4	Test for the losses and hydraulic coefficients in pipe and channel flows. (Cognitive Knowledge Level: Analyze)
CO 5	Analyze the metacentric height and radius of gyration of floating bodies. (Cognitive Knowledge Level: Analyze)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7		PO 8	PO 9	PO 10	PO 11
CO 1	3	2	1	2					2	1		1
CO 2	3	2	1	2					2	1		1
CO 3	3	2	1	2					2	1		1
CO 4	3	2	1	2					2	1		1
CO 5	3	2	1	2					2	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 Evaluation
- Class work/ Assessment : 10 marks
- Viva (Self Study) : 10 marks

Viva voce / test : 15 marks
Record : 5 marks

Experiment part : 70 marks
Viva voce : 30 marks

Guidelines for award of marks for the experiment part:

Preliminary work : 15 Marks
Implementing the work/Conducting the experiment : 25 Marks
Performance, result and inference : 30 Marks

KNOWLEDGE IS POWER

SYLLABUS

LIST OF EXPERIMENTS

Minimum **12** experiments are mandatory (Including study)

1	Study of taps, valves, pipe fittings, gauges, and plumbing tools to understand their function, design, and application in fluid systems.
2	Study of the hydraulic ram to understand its application in lifting water using minimal energy.
3	Performance test on Pelton wheel turbine
4	Performance test on Kaplan turbine
5	Best gate opening of Francis turbine
6	Performance test on Francis turbine
7	Performance test on a centrifugal pump
8	Performance test on a reciprocating pump
9	Performance test on a self-priming pump
10	Performance test on a gear pump
11	Measurement of metacentric height and radius of gyration in floating bodies
12	Calibration of a venturimeter to determine the coefficient of discharge
13	Calibration of a orifice meter to determine the coefficient of discharge
14	Calibration of a triangular or rectangular notch to determine the coefficient of discharge
15	Determination of Chezy's and Darcy's constants for pipe flow
16	Determination of Chezy's and Manning's coefficients for open channel flow
17	Determination of hydraulic coefficients of orifice under time for emptying method.

Reference Books

1. Yunus A. Cenegel, John M. Cimbala; Fluid Mechanics- Fundamentals and Applications, 4th ed., McGraw Hill, 2018.
2. Bansal R.K, A Textbook of Fluid Mechanics and Hydraulic Machines, 11th ed, Laxmi Publications, 2023.
3. Modi P.N and Seth S.M, Hydraulics and Fluid Mechanics Including Hydraulic Machines, Standard Book House, New Delhi, 22th Edition, 2019.
4. Graebel. W. P, Engineering Fluid Mechanics, Taylor & Francis, Indian Reprint, 2011.
5. Robert W. Fox, Alan T. McDonald, Philip J. Pritchard; Introduction to Fluid Mechanics; John Wiley & Sons, 10th Edition, 2019.
6. Franzini. J.B, Finnemore E.J, Fluid Mechanics with Engineering Applications; McGraw Hill, 10th Edition, 2001.

MAR ATHANASIUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution

Kothamangalam, Kerala, India

B.TECH MECHANICAL ENGINEERING

SEMESTER 4

(MINOR)

SYLLABUS

B24MEM41	MECHANICS OF MACHINES	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course provides an extensive study of motion analysis in mechanical systems, covering concepts such as displacement, velocity, and acceleration. It explores the operational principles behind cams, gears, and gear trains. The course also covers topics like static force analysis of planar mechanisms, gyroscopic dynamics, and the evaluation and correction of unbalance in rotating and reciprocating systems, equipping students with the knowledge and skills to solve advanced mechanical challenges.

Prerequisite

Nil

Course Outcomes

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

CO 1	Make use of the principles in the formation of mechanisms and their kinematics to perform velocity and acceleration analysis. (Cognitive Knowledge Level: Apply)
CO 2	Apply different techniques to synthesize cam profiles for different types of motion. (Cognitive Knowledge Level: Apply)
CO 3	Make use of the basic concepts of toothed gearing and apply kinematic principles to evaluate gear trains (Cognitive Knowledge Level: Apply)
CO 4	Apply static force analysis techniques to different mechanisms and evaluate the effects of gyroscopic couples. (Cognitive Knowledge Level: Apply)
CO 5	Utilize different methods to determine the unbalance in rotating and reciprocating masses. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	10	10	10
Understand	30	30	30
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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

KNOWLEDGE IS POWER

SYLLABUS

MODULE 1 (9 hours)

Introduction to kinematics and mechanisms - Terminology and definitions, degree of freedom, Grashof's criterion, Mechanisms and inversions. Velocity and acceleration in mechanisms, Instantaneous centre of rotation, Kennedy theorem.

MODULE 2 (8 hours)

Cams - classification of cam and followers - displacement diagrams, velocity and acceleration analysis of SHM, uniform velocity, uniform acceleration. Graphical cam profile synthesis.

MODULE 3 (10 hours)

Gears – Classification- terminology of spur gears – law of gearing -tooth profiles- involute spur gears- contact ratio - interference - backlash - gear standardization –interchangeability. Gear trains - simple and compound gear trains - planetary gear trains.

MODULE 4 (9 hours)

Static force analysis- Analysis of four bar linkages and slider crank mechanism, graphical method, Principle of virtual work. Gyroscopic couples-spin, precession and applied gyroscopic couple vectors-effects on the stability of two wheelers, four wheelers and air crafts, application of gyroscopes.

MODULE 5 (9 hours)

Static balancing-dynamic balancing-balancing of several masses in the same plane-several masses in different planes-graphical and analytical method. Balancing of reciprocating masses -Single cylinder engine-multi cylinder engine.

Text Books

1. S. S. Rattan, "Theory of Machines'', Tata Mc Graw Hill, 2019.
2. Ballaney P. L., ''Theory of Machines and Mechanisms'', Khanna Publishers, 2018.

Reference Books

1. C. E. Wilson, P. Sadler, ''Kinematics and Dynamics of Machinery'', Pearson Education,2014.
2. D. H. Myskza, ''Machines and Mechanisms Applied Kinematic Analysis'', Pearson Education, 2015.
3. G. Erdman, G. N. Sandor, ''Mechanism Design: Analysis and synthesis'', Vol I & II, Prentice Hall of India, 2001.
4. Ghosh, A. K. Malik, ''Theory of Mechanisms and Machines'', Affiliated East West Press, 2015.
5. J. E. Shigley, J. J. Uicker, ''Theory of Machines and Mechanisms'', McGraw Hill, 2023.
6. Norton, ''Kinematics and Dynamics of Machinery'', Tata McGraw Hill, 2009.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module1	**9**
1.1	Introduction to kinematics and mechanisms - Terminology and definitions.	1
1.2	Degree of freedom- Grashof's criterion.	2
1.3	Mechanisms and inversions.	2
1.4	Velocity and acceleration diagrams.	2
1.5	Instantaneous centre of rotation, Kennedy theorem.	2
	Module 2	**8**
2.1	Cams - classification of cam and followers.	2
2.2	Displacement diagrams, velocity and acceleration analysis of SHM.	2
2.3	Uniform velocity, uniform acceleration.	2
2.4	Graphical cam profile synthesis.	2
	Module 3	**10**
3.1	Gears – Classification- terminology of spur gears.	2
3.2	Law of gearing -Tooth profiles- involute spur gears.	2
3.3	Contact ratio - interference – backlash.	1
3.4	Gear standardization –interchangeability.	1
3.5	Gear trains - simple and compound gear trains.	2
3.6	Planetary gear trains.	2
	Module 4	**9**
4.1	Static force analysis- Analysis of four bar linkages and slider crank mechanism.	2
4.2	Graphical method.	2
4.3	Principle of virtual work.	1
4.4	Gyroscopic couples-spin, precession and applied gyroscopic couple vectors.	2
4.5	Effects on the stability of, Four wheelers, two wheelers and air crafts.	2
	Module 5	**9**
5.1	Static balancing-dynamic balancing.	1
5.2	Balancing of several masses in the same plane.	2
5.3	Several masses in different planes-graphical method.	2
5.4	Analytical method.	2
5.5	Balancing of reciprocating masses -Single cylinder engine, Multi cylinder engine.	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. What is the difference between a kinematic link and a kinematic pair?
2. Explain the inversions of a four-bar mechanism.
3. What is Grashof's criterion and how it determines the degree of freedom of a mechanism?
4. What are the different types of mechanism?

Course Outcome 2 (CO2):

1. What are the different types of cams and followers?
2. What is the significance of the dwell period in a cam profile?
3. What are the different methods of cam profile construction?
4. How can displacement diagrams be used in the analysis of cam motions?

Course Outcome 3 (CO3):

1. What are the different classifications of gears?
2. With a neat sketch explain the terminology of spur gears.
3. What is meant by the contact ratio in gears? Explain its importance in gear design.
4. What is interference in gears, and how can it be minimized during gear design?

Course Outcome 4 (CO4):

1. Perform the static force analysis of a slider-crank mechanism under various loading conditions.
2. Explain the principle of virtual work.
3. Explain gyroscopic effect.
4. How does the precession of a gyroscope affect the motion of a vehicle or aircraft?

Course Outcome 5 (CO5):

1. What is the difference between static and dynamic balancing?
2. Determine the magnitude and location of the balancing masses needed to balance the unbalanced masses rotating in different planes.
3. How can reciprocating masses be balanced in a single-cylinder engine?
4. How is dynamic balancing achieved in multi-cylinder configuration?

KNOWLEDGE IS POWER

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FOURTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: **B24MEM41**

Course Name: **MECHANICS OF MACHINES**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What do you mean by degree of freedom?
2. Explain Kennedy's theorem related to the instantaneous centres.
3. What are the different types of followers used in cam mechanisms?
4. What is meant by rise, dwell, and fall in cam-follower motion?
5. What do you mean by backlash in gears?
6. What are the different classifications of gear?
7. Explain the principal of virtual work.
8. How does gyroscope help in the guidance of ships?
9. Differentiate between static balancing and dynamic balancing.
10. What do you mean by primary and secondary unbalance in reciprocating engines?

PART B

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

Module 1

11. For a four-bar mechanism ABCD with the following dimensions, calculate the velocity of joint C and the angular velocities of links CD and BC, if the angular velocity of link AB is 10 rad/sec in the clockwise direction. The dimensions are: AB = 30 cm, BC = CD = 35 cm, AD (fixed) = 60 cm, and angle BAD = 60. Solve using the graphical method. (14 marks).

OR

12. a) Differentiate between a machine and structure. (4 marks)

b) What is meant by inversion of a mechanism? Describe with suitable sketches the inversions of a double slider- crank chain. (10 marks)

Module 2

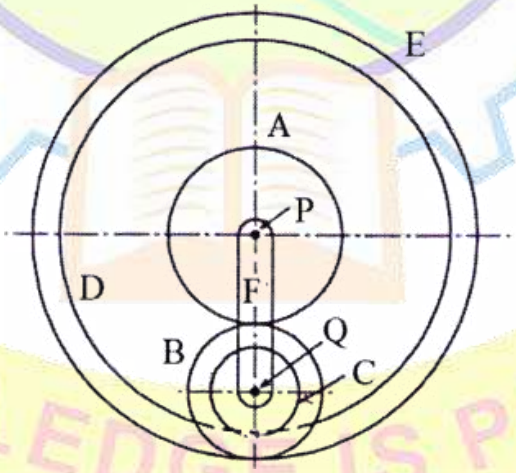
13. A cam with 25mm minimum radius is rotating clockwise at 480 rpm to give the follower motion to a roller of 20mm diameter. Lift = 40mm, follower rises during 120^o of cam rotation, dwells for 45^o of cam rotation, follower to return during 150^o of cam rotation and the follower dwells for the remaining period. The rise and return of the follower take place with cycloidal motion. The line of stroke of the follower is offset by 10mm from the center of the cam. Construct the cam profile and determine the maximum velocity and acceleration during rise and return stroke. (14 marks)

OR

14. A disc cam profile is to be synthesized to provide simple harmonic motion (SHM) to a knife-edge offset follower during the outstroke of 50 mm. The cam's motion consists of the following: an ascent angle of 120°, dwell for 60°, a descent angle of 90°, and the follower dwells for the remaining cam rotation. The minimum radius of the cam is 50 mm. (14 marks)
    a. Draw the cam profile when the knife-edge follower is offset by 20 mm.
    b. Calculate the maximum velocity and acceleration during ascent and descent when the camshaft revolves at 240 rpm, and plot the velocity and acceleration diagrams.

Module 3

15. In a compound epicyclic gear train, as shown in the diagram, gears A, D, and E rotate freely on the axis P. The compound gears B and C rotate together on axis Q at the end of arm F. All gears have equal module, and the number of teeth on gears A, B, and C are 18, 45, and 21, respectively. Gears D and E are annular gears. Gear A rotates at 120 rpm counter-clockwise, and gear D rotates at 450 rpm clockwise. Determine the speed and direction of the arm F and gear E.



(14 marks)

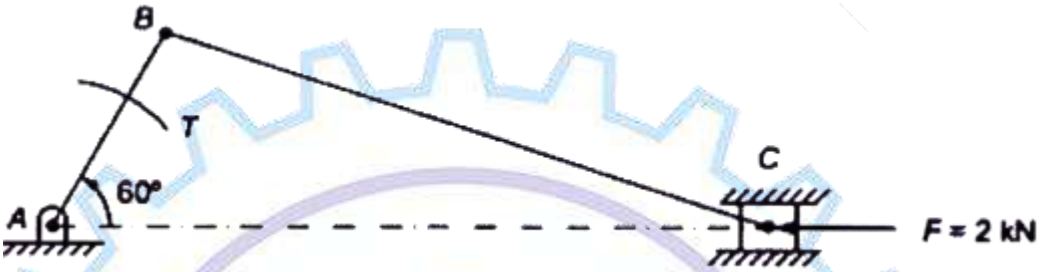
OR

16. a) Two 20° involute spur gears mesh externally and give a velocity ratio of 3. The module is 3mm and the addendum is equal to 1.1 module. If the pinion rotates at 120 rpm, determine the minimum number of teeth on each wheel to avoid interference and the contact ratio. (8 marks)

    b) Explain the functioning of a reverted gear train? Derive its velocity ratio. (6 marks)

Module 4

17. In the slider-crank mechanism shown in figure, where the force applied to the slider is 2 kN, and the link dimensions are as follows: AB = 80 mm, BC = 240 mm, and the crank angle θ=60∘. Determine the forces acting on the various links and the driving torque T. (14 marks)



OR

18. An airplane flying at 240 km/h turns left and completes a quarter cycle with a radius of 60 m. The mass of the engine and propeller is 450 kg, with a radius of gyration of 320 mm. The engine speed is 2000 rpm in the clockwise direction when viewed from the rear. Calculate the gyroscopic couple acting on the aircraft. (14 marks)

Module 5

19. Four masses m1, m2, m3, and m4 have values of 200 kg, 300 kg, 240 kg, and 260 kg, respectively. The corresponding radii of rotation are 0.2 m, 0.5 m, 0.25 m, and 0.3 m, respectively, with the angles between successive masses being 45°, 75°, and 135°. Determine the position and magnitude of the balancing mass required, assuming its radius of rotation is 0.2 m. (14 marks)

OR

20. An inside-cylinder locomotive has its cylinder centerlines 0.7 m apart and a stroke of 0.6 m. The rotating mass per cylinder is equivalent to 150 kg at the crank pin, and the reciprocating mass per cylinder is 180 kg. The wheel centerlines are 1.5 m apart, and the cranks are at right angles. The entire rotating and half of the reciprocating masses are to be balanced by masses placed at a radius of 0.6 m. Calculate the fluctuation in rail pressure under one wheel, the variation of tractive effort, and the magnitude of the swaying couple at a crank speed of 300 rpm. (14 marks)

KNOWLEDGE IS POWER

B24MEM42	THERMODYNAMICS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

Engineering thermodynamics explores the principles of energy, its transformations, and its interactions with matter. This course delves into fundamental concepts such as heat, work, and the laws of thermodynamics, which are essential for designing efficient systems, including engines and power plants. A strong foundation in thermodynamics is crucial for tackling challenges related to energy production, consumption, and environmental sustainability, making it a key discipline in advancing modern engineering solutions.

Prerequisite

Nil

Course Outcomes

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

CO 1	Make use of Zeroth law of Thermodynamics to define temperature and to apply its basic principles to thermal systems (Cognitive Knowledge Level: Apply)
CO 2	Apply first law of thermodynamics to analyse energy interactions in non-flow processes (Cognitive Knowledge Level: Apply)
CO 3	Apply first law of thermodynamics to analyse energy interactions and mass balance in flow (Cognitive Knowledge Level: Apply)
CO 4	Understand second law to various processes to appreciate directionality of processes (Cognitive Knowledge Level: Understand)
CO 5	Explain various power generating thermodynamic cycles. (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			1			1
CO 2	3	2	1	2		1			1			1
CO 3	3	2	1	2		1			1			1
CO 4	3	2	1	2		1			1			1
CO 5	3	2	1	2					1			1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	10	10	10
Understand	40	40	40
Apply	50	50	50
Analyse			
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

KNOWLEDGE IS POWER

SYLLABUS

MODULE 1 (8 hours)

Role of Thermodynamics and it's applications in Engineering and Science –Basic Concepts Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic System and Control Volume, Surrounding, Boundaries, Types of Systems, Universe, Thermodynamic properties, Process, Cycle, Thermodynamic Equilibrium, Quasi – static Process, State, Point and Path function. Zeroth Law of Thermodynamics, Measurement of Temperature, reference Points, Temperature Scales.

MODULE 2 (10 hours)

First law of thermodynamics for Non-Flow process: Forms of Energy, Work - Pdv work and other types of work transfer, free expansion work, heat and heat capacity. First law of Thermodynamics - First law applied to Non flow Process

MODULE 3 (8 hours)

First law of thermodynamics for Flow process: examples of control volume analysis, Flow work, Enthalpy- specific heats, First law applied to Flow Process, Mass and Energy balance in simple steady flow process. Applications of SFEE, Limitations of the First Law.

MODULE 4 (10 hours)

Second Law of Thermodynamics, Thermal Reservoir, Heat Engine, Heat pump – Kelvin-Planck and Clausius Statements, Equivalence of two statements, Reversibility, Irreversible Process, Causes of Irreversibility, Carnot's theorem and its corollaries, Absolute Thermodynamic Temperature scale.

MODULE 5 (9 hours)

Review of Power Generation Cycles- Ideal Rankine Cycle -Effect of Temperature and Pressure on Rankine Cycle, Ideal Brayton Cycle, Turbine work, Compressor work and Efficiency. Review of Vapour Compression Refrigeration cycle-Basic schematic, components

Text Books

1. Yunus Cengel, et al , "Thermodynamics: An Engineering Engineering Approach", McGraw Hill, 9th Edition, 2019

Reference Books

1. Moran J., Shapiro N. M., "Fundamentals of Engineering Thermodynamics", Wiley, 9th Edition, 2018
2. R. E. Sonntag and C. Borgnakke, "Fundamentals of Thermodynamics", Wiley, 8th Edition, 2012
3. P. K. Nag, "Engineering Thermodynamics", McGraw Hill, 6th Edition, 2017

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module1	**8**
1.1	Role of Thermodynamics and it's applications in Engineering and Science	1
1.2	Basic Concepts Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic System and Control Volume, Surrounding, Boundaries, Types of Systems, Universe	2
1.3	Thermodynamic properties, Process, Cycle, Thermodynamic Equilibrium, Quasi-static Process, State, Point and Path function.	2
1.4	Zeroth Law of Thermodynamics, Measurement of Temperature,	1
1.5	Reference Points, Temperature Scales.	2
	Module 2	**10**
2.1	First law of thermodynamics for non-flow processes	2
2.2	Forms of Energy	1
2.3	Work - Pdv work and other types of work transfer, free expansion work	2
2.4	heat and heat capacity	1
2.5	First law of Thermodynamics	2
2.6	First law applied to Non flow Process-Problems	2
	Module 3	**8**
3.1	Flow processes-examples of control volume analysis	2
3.2	Concept of Flow work, Enthalpy	2
3.3	Specific heats, First law applied to Flow Process	1
3.4	Mass and Energy balance in simple steady flow process.	1
3.5	Applications of SFEE, Limitations of the First Law	2
	Module 4	**10**
4.1	Second Law of Thermodynamics, Thermal Reservoir, Heat Engine, Heat pump – Kelvin-Planck and Clausius Statements	1
4.2	Equivalence of two statements, Reversibility	2
4.3	Irreversible Process, Causes of Irreversibility	1
4.4	Carnot theorem	1
4.5	Carnot Cycle-Significance of Carnot efficiency	2
4.6	Carnot theorem corollaries	1
4.7	Absolute Thermodynamic Temperature scale.	2
	Module 5	**9**
5.1	Review of Power Generation Cycles	1
5.2	Ideal Rankine Cycle	1
5.3	Effect of Temperature and Pressure on Rankine Cycle	2
5.4	Ideal Brayton Cycle, Turbine work, Compressor work and Efficiency.	2
5.5	Review of Vapour Compression Refrigeration cycle	2
5.6	Basic schematic, Functions of basic components, COP	1
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Discuss the different types of systems.
2. Differentiate between Intensive and extensive properties
3. Explain various temperature scales used in engineering

Course Outcome 2 (CO2):

1. State first law of thermodynamics for non flow process.
2. A mass of 2.4 kg of air at 150 kPa and 12°C is contained in a gas – tight, frictionless piston –cylinder device. The air is now compressed to a final pressure of 600 kPa . During this process, heat is transferred from the air such that the temperature inside the cylinder remains constant. Calculate the work input during this process.
3. What are the limitations of first law?

Course Outcome 3 (CO3):

1. Carbon dioxide enters an adiabatic nozzle steadily at 1 MPa and 500°C with a mass flow rate of 600 kg/hr and leaves at 100 kPa and 450 m/s. The inlet area of the nozzle is 40 cm2. Determine (a)the inlet velocity and (b) the exit temperature
2. Derive Steady flow energy equation.
3. Analyse heat transfer in heat exchanger using Steady flow energy equation.

Course Outcome 4 (CO4):

1. State the second law of thermodynamics.
2. Prove equivalence of second law statements.
3. State and explain the significance of Carnot theorem.

Course Outcome 5 (CO5):

1. Plot the T-s diagram of Rankine Cycle. Explain the processes using a schematic.
2. Explain the working of a vapor compression refrigeration cycle.
3. How can the efficiency of a Rankine cycle be improved?

KNOWLEDGE IS POWER

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FOURTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: **B24MEM42**

Course Name: **THERMODYNAMICS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define thermodynamics. List a few of its applications
2. Differentiate between intensive and extensive properties.
3. Differentiate between heat and work.
4. State the first law of thermodynamics for a closed system
5. Define internal energy and enthalpy.
6. Apply the SFEE across a nozzle.
7. State second law of thermodynamics.
8. An inventor claims to have developed an engine that delivers 26 kJ of work using 82 kJ of heat while operating between temperatures 120°C and 30°C. Is his claim valid ? Give the reason for your answer.
9. How can you estimate the pump work in Rankine cycle?
10. Define COP of a refrigerator.

PART B

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

Module 1

11. a) What is meant by thermodynamic equilibrium? What are the essential conditions for a system to be in thermodynamic equilibrium? (7 marks)

    b) Express the temperature of 91 ^{o}C in (i) Fahrenheit (ii) Kelvin (iii) Rankine. (7 marks)

OR

12. a) Explain macroscopic and microscopic approach to thermodynamics. (7 marks)

b) With the aid of a suitable diagram, explain the working of constant volume gas thermometer. (7 marks)

Module 2

13. A mass of 2.4 kg of air at 150 kPa and 12 ^{o}C is contained in a gas – tight, frictionless piston –cylinder device. The air is now compressed to a final pressure of 600 kPa. During this process, heat is transferred from the air such that the temperature inside the cylinder remains constant. Calculate the work input during this process (14 marks)

OR

14. Explain various forms of energy. What are the different forms in which internal energy is stored. (14 marks)

Module 3

15. State the general energy balance equation for an unsteady flow system and from it, derive the energy balance equation for a bottle filling process, stating all assumptions. (14 marks)

OR

16. A turbine operates under steady flow conditions, receiving steam at the following conditions: pressure 1.2 MPa, temperature 188°C, enthalpy 2785 kJ/kg, velocity 33.3 m/s and elevation 3m. The steam leaves the turbine at the following conditions: pressure 20 kPa, enthalpy 25kJ/kg, velocity 100 m/s, and elevation 0 m. Heat is lost to the surroundings at the rate of 0.29 kJ/s. If the rate of steam flow through the turbine is 0.42kg/s, what is the power output of the turbine in kW? (14 marks)

Module 4

17. State the Kelvin-Planck and Clausisus statements of the second law of thermodynamics and prove their equivalence. (14 marks)

OR

18. State and prove corollaries of Carnot theorem (14 marks)

Module 5

19. Explain Rankine cycle with neat schematics. Explain the effect of operating parameters on cycle efficiency. (14 marks)

OR

20. Explain vapor compression refrigeration with a neat labelled sketch. Derive an expression for COP of a vapor compression cycle. (14 marks)

B24MEM43	MANUFACTURING PROCESS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course explores the techniques and methods used to convert raw materials into finished products. It covers a diverse array of manufacturing processes, such as casting, machining, welding, and additive manufacturing, all of which play a crucial role in industries like automotive, aerospace, electronics, and consumer goods. Mastering these processes is key to designing efficient production systems, maintaining product quality, and minimizing costs. Students will gain a deep understanding of the principles, tools, and technologies that power modern manufacturing, equipping them for careers in engineering, production management, and industrial design.

Prerequisite

Nil

Course Outcomes

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

CO 1	Explain the basics and various types of casting. (Cognitive Knowledge Level: Understand)
CO 2	Understand the fundamentals and mechanisms associated with powder metallurgy (Cognitive Knowledge Level: Understand)
CO 3	Compare various welding techniques. (Cognitive Knowledge Level: Understand)
CO 4	Apply the basics of metal forming and shaping processes (Cognitive Knowledge Level: Apply)
CO 5	Outline the fundamentals of photolithography. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	20	30
Understand	60	50	40
Apply		30	30
Analyze			
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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

KNOWLEDGE IS POWER

SYLLABUS

MODULE 1 (10 hours)

Overview of manufacturing processes and their importance in engineering - Classification of manufacturing processes: primary, secondary, and tertiary processes - Fundamentals of casting processes: patterns, molds, melting, pouring, and solidification - Metal casting:-sand casting:- shell mold casting, evaporative pattern casting, investment casting, permanent mold casting, vacuum casting, slush casting, pressure casting, die casting, centrifugal casting, squeeze casting - Defects in casting and their remedies.

MODULE 2 (9 hours)

Powder metallurgy - powder production methods: atomization and electrolysis - powder characteristics: size and shape, blending, mixing: types of devises used, compaction of metal powders: pressing and rolling – different types - sintering fundamentals and mechanisms - infiltration and impregnation, advantages, dis advantages and applications

MODULE 3 (9 hours)

Welding - arc welding - consumable electrodes; heat affected zone; quality; case study and weld ability of metals – non-consumable electrodes; electron and laser beam welding; heat affected zone; power density - weld quality; case study; application - Brazing:- filler metals, fluxes, joint strength; brazing methods, applications - Soldering: - solders and fluxes - soldering methods - solder ability, case study, applications.

MODULE 4 (9 hours)

Fundamentals of metal forming: plastic deformation and yield criteria - Forging: open-die, closed-die, and impression-die forging processes - Rolling: types of rolling mills, rolling defects, and applications - Extrusion and drawing processes: principles, types, and applications - Sheet metal forming processes: bending, stretching, shearing, and deep drawing.

MODULE 5 (8 hours)

Photo lithography - different lithography methods - Etching, wet etching, dry etching- diffusion and Ion implantation metallization and testing - wire bonding and packing - yield and reliability - fabrication of micro electro mechanical devices

Text Book

1. Serope Kalpakjian, Steven R. Schmid - Manufacturing Engineering and Technology, 7th Edn. Pearson.

Reference Books

1. P. N. Rao, Manufacturing Technology, McGraw Hill.
2. G. Boothroyd, Fundamentals of Manufacturing Processes, CRC Press.
3. J. A. Schey, Introduction to Manufacturing Processes, McGraw Hill.

COURSE CONTENTS AND LECTURE SCHEDULE

No.	Topic	No. of Lectures/ Tutorial hours
	Module1	**10**
1.1	Overview of manufacturing processes and their importance in engineering	2
1.2	Classification of manufacturing processes	1
1.3	Fundamentals of casting processes	1
1.4	Metal casting types – sand casting, shell mold casting, evaporative pattern casting, investment casting, permanent mold casting	1
1.5	Investment casting, permanent mold casting	1
1.6	Vacuum casting, slush casting, pressure casting	1
1.7	Die casting, centrifugal casting, squeeze casting	1
1.8	Casting defects and Remedies	2
	Module 2	**9**
2.1	Introduction to powder metallurgy	2
2.2	Powder production methods	1
2.3	Powder characteristics - size and shape	2
2.4	Blending, mixing and compaction of metal powders	2
2.5	Sintering fundamentals and mechanisms	1
2.6	Infiltration and impregnation, advantages, disadvantages and applications	1
	Module 3	**9**
3.1	Introduction to welding and classifications	2
3.2	Arc welding – consumable electrodes	1
3.3	HAZ and weldability of metals with case study	2
3.4	Arc welding – non-consumable electrodes	1
3.5	Electron beam and laser beam welding	1
3.6	Soldering & brazing – case study and applications	2
	Module 4	**9**
4.1	Fundamentals of metal forming	1
4.2	Plastic deformation and yield criteria	1
4.3	Fundamentals of forging and classifications	2
4.4	Rolling - types, defects and applications	2
4.5	Extrusion and drawing processes - principles, types, and applications	1
4.6	Sheet metal forming processes	1
4.7	Bending, stretching, shearing, and deep drawing	1
	Module 5	**8**
5.1	Fundamentals of photo lithography	1
5.2	Different lithography methods – Etching: wet etching, dry etching	2
5.3	Diffusion and Ion implantation metallization and testing	1
5.4	Wire bonding and packing	1
5.5	Yield and reliability	1
5.6	Fabrication of micro electro mechanical devices	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. What is the importance of allowance in patterns
2. List out various types of casting defects.

Course Outcome 2 (CO2):

1. What are the factors affecting the sintering process in powder metallurgy?
2. How do surface preparations affect the strength of the joint in the welding processes

Course Outcome 3 (CO3):

1. Explain why vacuum is required in electron beam welding
2. What are the different types of lasers

Course Outcome 4 (CO4):

1. What are the defects in the forging process
2. List out the main steps involved in the lithography process

Course Outcome 5 (CO5):

1. What is the purpose of prebaking and post baking in lithography
2. What are the types of metallization?

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MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FOURTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: **B24MEM43**

Course Name: **MANUFACTURING PROCESS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Identify and give details on the casting process used for the manufacturing of a cast iron pipe.
2. Differentiate between the brazing and the soldering processes.
3. Give any two limitations of the hot extrusion process.
4. Differentiate between the dry etching and the wet etching processes.
5. Give any two functions of the flux used in the arc welding process.
6. Why does the powder metallurgy process used for the making of the components which contains tungsten or platinum as elements.
7. Name and explain the casting process used for the manufacture of intricate shaped components.
8. Give any two advantages of the Laser Beam Welding process.
9. What is the major drawback of the electron beam lithography process.
10. Why spanners are made by forging process?

PART B

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

Module 1

11. a) What is the function of a pattern? Write short notes on any three types of patterns. (8 Marks)

    b) Write down the method and application of slush casting process. (6 Marks)

OR

12. a) Explain the hot chamber die casting process with a neat figure. (8 Marks)

    b) Explain various casting defects with neat sketches. (6 Marks)

Module 2

13. a) Explain the Plasma Arc Welding process with a neat sketch. (8 Marks)
    b) Explain the terms 'weldability' and 'heat affected zone'. (6 Marks)

OR

14. a) Explain the various steps involved in the making of components by using the powder metallurgy process. (8 Marks)
    b) Give the various advantages of powder metallurgy process. (6 Marks)

Module 3

15. a) Explain the submerged arc welding process with a neat sketch. (8 Marks)
    b) Describe the principle of arc welding process. (6 Marks)

OR

16. a) Write short notes on the brazing process. Name the filler material and the flux used in the brazing process. (8 Marks)
    b) Describe the soldering process and its applications. (6 Marks)

Module 4

17. a) Explain the direct extrusion process with a neat figure. (8 Marks)
    b) Compare the cold extrusion process and the hot extrusion process. (6 Marks)

OR

18. a) Explain the wire drawing process with a neat figure. (8 Marks)
    b) Explain the principle and the method of the photolithography technique. (6 Marks)

Module 5

19. a) Describe the ion implantation process with a neat figure. (8 Marks)
    b) Explain the bulk and the surface micromachining processes. (6 Marks)

OR

20. a) Describe the electron beam lithography process. (6 Marks)
    b) Explain the wire bonding and packaging process. (8 Marks)

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MAR ATHANASIUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution
Kothamangalam, Kerala, India

B.TECH MECHANICAL ENGINEERING

SEMESTER 4

(HONOURS)

SYLLABUS

B24MEH41	DESIGN OF HYDRAULIC AND PNEUMATIC EQUIPMENTS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course provides students with a comprehensive understanding of fluid power principles, focusing on the operation, and maintenance of hydraulic and pneumatic systems. Students will explore the fundamental concepts of fluid mechanics, pump classifications, actuators, control valves, and circuit design. The course also emphasizes troubleshooting techniques and industrial applications, enabling students to diagnose faults and optimize system performance. By the end of the course, students will be equipped to apply fluid power technology in various industrial applications.

Prerequisite: Nil

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

CO 1	Explain the fundamental principles of fluid power and its applications in hydraulic systems. (Cognitive Knowledge Level: Understand)
CO 2	Outline the construction, working, and selection of hydraulic actuators and control components used in industrial applications. (Cognitive Knowledge Level: Understand)
CO 3	Explain different hydraulic circuits and systems used in industrial processes and their functional significance. (Cognitive Knowledge Level: Understand)
CO 4	Model pneumatic and electro-pneumatic circuits for automation and industrial control. (Cognitive Knowledge Level: Apply)
CO 5	Develop skills in troubleshooting, diagnosing faults, and optimizing the performance of hydraulic and pneumatic systems. (Cognitive Knowledge Level: Apply)

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	30	10	10
Understand	70	50	50
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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

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SYLLABUS

Module 1 (6 hours)

Fluid power principles and hydraulic pumps: Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids - Properties of fluids and selection – Basics of Hydraulics – Pascal's Law, Sources of Hydraulic power, Pump Classification – Construction, Working, Design, Advantages, and Disadvantages.

Module 2 (9 hours)

Hydraulic actuators and control components: Hydraulic Actuators: Cylinders – Types and construction, Application, Hydraulic cushioning – Hydraulic motors - Control Components: Direction Control, Flow control and pressure control valves – Types, Construction and Operation – Servo and Proportional valves

Module 3 (11 hours)

Hydraulic circuits and systems: accumulators, Intensifiers, Industrial hydraulic circuits – Regenerative, Pump Unloading, Double-Pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Synchronization, Fail-Safe, Speed Control, Hydrostatic transmission, Mechanical hydraulic servo systems.

Module 4 (9 hours)

Pneumatic and electro pneumatic systems: Properties of air – Perfect Gas Laws – Compressor– Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Design of Pneumatic circuit – Cascade method – Electro Pneumatic System.

Module 5 (10 hours)

Trouble shooting and applications: Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems, Design of hydraulic circuits for Drilling, Surface grinding, Press and Forklift applications. Design of Pneumatic circuits for Pick and Place applications and tool handling in CNC Machine tools.

Text Books

1. Anthony Esposito, "Fluid Power with Applications", Prentice Hall, 2009.
2. James A. Sullivan, "Fluid Power Theory and Applications", Fourth Edition, Prentice Hall, 1997.

References

1. Shanmugasundaram K., "Hydraulic and Pneumatic Controls". Chand & Co, 2006.
2. Majumdar S.R., "Oil Hydraulics Systems – Principles and Maintenance", Tata McGraw Hill, 2001

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module1	**6**
1.1	Introduction to Fluid power, Advantages and Applications	1
1.2	Fluid power systems, Types of fluids	1
1.3	Properties of fluids and selection, Basics of Hydraulics, Pascal's Law	1
1.4	Sources of Hydraulic power, Pump Classification – Construction	2
1.5	Working, Design, Advantages, Disadvantages	1
	Module 2	**9**
2.1	Hydraulic Actuators: Cylinders, Types and construction, Application	2
2.2	Hydraulic cushioning	1
2.3	Hydraulic motors, Control Components : Direction Control	2
2.4	Flow control Valve, Pressure control valves, Types, Construction and Operation	2
2.5	Servo and Proportional valves, Servo and Proportional valves	2
	Module 3	**11**
3.1	Accumulators, Intensifiers	1
3.2	Industrial hydraulic circuits	2
3.3	Regenerative pump, Pump Unloading	1
3.4	Double-Pump, Pressure Intensifier	2
	Air-over oil, Sequence	1
	Reciprocation & Synchronization	1
	Fail-Safe, Speed Control	1
	Hydrostatic transmission, Mechanical hydraulic servo systems.	2
	Module 4	**9**
4.1	Properties of air, Perfect Gas Laws	1
4.2	Compressor – Filters, Regulator	2
4.3	Lubricator, Muffler	1
4.4	Air control Valves, Quick Exhaust Valves	2
4.4	Pneumatic actuators, Design of Pneumatic circuit, Cascade method	2
4.5	Electro Pneumatic System	1
	Module 5	**10**
5.1	Installation of Pneumatic systems, Selection, Maintenance	2
5.2	Trouble Shooting and Remedies in Hydraulic and Pneumatic systems	2
5.3	Design of hydraulic circuits for Drilling	1
5.4	Design of hydraulic circuits for Surface Grinding	1
5.5	Press and Forklift applications	1
5.6	Design of Pneumatic circuits for Pick and Place applications and tool handling in CNC Machine tools.	3
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Write short notes about types of fluids used in the fluid power systems
2. Explain the working principle of external Gear pump and Internal Gear pump with neat sketch.

Course Outcome 2 (CO2):

1. How do you select hydraulic pipes for a hydraulic system?
2. Mention the significance of telescopic cylinder with industrial application

Course Outcome 3 (CO3):

1. Discuss the construction and working of a Mechanical hydraulic servo system with a diagram
2. Explain the working principle of following (1) 3/2 Way Valve (2) 4/2 way valve (3) 4/3 way valve

Course Outcome 4 (CO4):

1. Describe pneumatic Actuators and explain the types of linear Actuators
2. Explain the various approaches for entering the program into the PLC

Course Outcome 5 (CO5):

1. Explain in detail about how the failure and troubleshooting is carried out in hydraulic system
2. Describe the basic concepts of low-cost automation with suitable example

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MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FOURTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: **B24MEH41**

Course Name: **DESIGN OF HYDRAULIC AND PNEUMATIC EQUIPMENTS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What are the advantages of fluid power systems over mechanical and electrical systems?
2. State Pascal's Law and explain its significance in hydraulic systems.
3. Differentiate between hydraulic cylinders and hydraulic motors
4. What are the different types of hydraulic directional control valves?
5. How does a regenerative hydraulic circuit improve efficiency?
6. What is a fail-safe circuit, and where is it used?
7. Explain the function of a filter-regulator-lubricator (FRL) unit in a pneumatic system
8. How does an electro-pneumatic system differ from a conventional pneumatic system?
9. What are the common causes of hydraulic system failures?
10. How do you diagnose and fix a pressure drop in a hydraulic system?

PART B

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

Module 1

11. What are the types of piston pump? Explain the working principle of radial piston pumps with neat sketch?

OR

12. Explain Pascal's Law and its significance in hydraulic systems. How does Pascal's Law contribute to the efficiency and functionality of hydraulic systems? Provide real-world

examples of how this law is applied in fluid power systems.

Module 2

13. Explain the working principles and applications of hydraulic motors in fluid power systems. How do hydraulic motors differ from hydraulic cylinders, and what are the specific advantages they offer in motion control?

OR

14. Examine the various types of control valves used in hydraulic systems. Discuss their construction, operation, and the role they play in regulating the performance and safety of hydraulic systems.

Module 3

15. Discuss the function and working principle of accumulators and intensifiers in hydraulic circuits. How do these components enhance the efficiency and performance of hydraulic systems, and what are their specific applications in industrial settings?

OR

16. Examine the different types of industrial hydraulic circuits, such as regenerative, pump unloading, and double-pump circuits. Explain the principles behind each circuit type and their respective advantages in optimizing system performance and reducing energy consumption.

Module 4

17. Discuss the role of key components in a pneumatic system, including compressors, filters, regulators, lubricators, and mufflers. How does each component contribute to the overall efficiency and reliability of the system, and what considerations should be made during their selection and maintenance?

OR

18. Examine the design of pneumatic circuits using the Cascade method and the integration of electro-pneumatic systems. How does the Cascade method aid in designing efficient pneumatic circuits, and what advantages do electro-pneumatic systems provide in terms of automation and control in industrial processes?

Module 5

19. Explain the key factors involved in the selection, installation, and maintenance of hydraulic and pneumatic systems. Discuss their importance in ensuring system efficiency and reliability.

OR

20. Compare and contrast hydraulic and pneumatic systems in terms of design, operation, troubleshooting, and applications. Provide examples of industrial uses where each system is preferred.

B24MEH42	ADVANCED FLUID MECHANICS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course explores the fundamental principles and methods of both compressible and incompressible flows, with a strong focus on applying core fluid mechanics concepts to real-world problems. By the end of the course, students will have a solid understanding of flow dynamics and the skills to analyze various fluid mechanical systems effectively.

Prerequisite: Nil

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

CO 1	Model physical fluid dynamics systems using the application of proper governing equations with suitable boundary conditions. (Cognitive Knowledge Level: Apply)
CO 2	Apply conservation equations to analytically solve simple fluid dynamics problems on the broad area of potential flows, vortex flows and laminar flows. (Cognitive Knowledge Level: Apply)
CO 3	Understand boundary layer theory and instability theory and apply these in real fluid flow systems. (Cognitive Knowledge Level: Apply)
CO 4	Categorize compressible flows and apply suitable governing equations for isentropic flows. (Cognitive Knowledge Level: Apply)
CO 5	Examine shock waves and its consequences in physical systems. (Cognitive Knowledge Level: Apply)

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	10	10	10
Understand	30	30	30
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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

KNOWLEDGE IS POWER

SYLLABUS

Module 1 (10 hours)

A brief review of some preliminary concepts of Fluid Mechanics.

Fluid Kinematics: Lagrangian and Eulerian Approach- Acceleration of fluid flows- Reynolds Transport Theorem. Linear and angular Deformation-Concept of Vorticity, Potential Function and Stream function Governing Equations: Derivation of the general form of conservation of mass- Navier Stokes Equation- Energy Equation in differential and integral forms - Control volume analysis.

Module 2 (10 hours)

Vorticity Dynamics: Vortex lines and tubes, Role of viscosity in rotational and irrotational vortices- Kelvin's circulation theorem-Interaction of vortices.

Irrotational Flow Theory: Application of complex variables- Source, Sink, Doublet- Flow at a wall angle- Flow past a half body- Flow past a circular cylinder with circulation- Forces on 2D body.

Exact Solutions of N-S equations: Steady flow in pipes. Steady flow between parallel plates and concentric cylinders- Axi-symmetric flows; Impulsively started plates: Similarity solutions.

Module 3 (9 hours)

Boundary Layer Theory: Boundary Layer approximations- Measures of boundary layer thickness- Blasius Solution- Momentum Integral Equation- effect of pressure gradient- Separation- Flow past a circular cylinder and sphere- Dynamics of sports balls.

Flow Instabilities (Theory only): Introduction- Method of normal modes- Thermal instability- K-H instability.

Module 4 (8 hours)

Introduction to Compressible flows- Speed of Sound- Basic equation for 1 D flow.

Isentropic flow with variable area: Stagnation and Critical conditions, Mass flow rate, Geometric chocking, Isentropic flow through C-D nozzle.

Fanno flow: Adiabatic flow in constant area duct with friction, Fanno line, Friction choking and its consequences.

Module 5 (8 hours)

Rayleigh flow: Frictionless flow in constant area duct with heat transfer, Rayleigh line, Thermal choking and its consequences.

Standing normal shocks-– Fundamental relations-R-H equations- Stationary normal shock waves in C-D Nozzles; Oblique Shocks: Fundamental relations, property relationships, θ-β-M diagram. Shock Reflection and Intersections- shock tube.

References

1. Pijush K. Kundu, and Ira M. Cohen. "Fluid Mechanics". 4th ed. Academic Press, 2008.

2. James John & Theo Keith, “Gas Dynamics”, Pearson Education, 2006.
3. White F. M., “Viscous Fluid Flow”, Mc Graw Hill Pub., 2006
4. Schlichting, H., and K. Gersten. “Boundary Layer Theory”. Springer, 2000.
5. John D Anderson, “Modern Compressible Flow”, McGraw Hill, 2003
6. Shapiro A. H., “The Dynamics and Thermodynamics of Compressible Flow; Vol 1”, 1953.
7. Annual Review of Fluid Mechanics.

COURSE CONTENTS AND LECTURE SCHEDULE

Sl. No	Topic	No. of Lecture/ Tutorial hours
Module 1		**(10 Hours)**
1.1	A brief review of some preliminary concepts of Fluid Mechanics	2
1.2	Lagrangian and Eulerian Approach- Acceleration of fluid flows- Stream line, Path line and Streak line	1
1.3	Fluid deformation, Reynolds Transport Theorem	1
1.4	Concept of Vorticity, Potential Function, and Stream Function	1
1.5	Conservation of mass	1
1.6	Conservation of momentum, Navier- Stokes equation	2
1.7	Conservation of energy; Control volume Analysis-Numerical Problems	2
Module 2		**(10 Hours)**
2.1	Vorticity Dynamics: Vortex lines and tubes, Role of viscosity in rotational and irrotational vortices	2
2.2	Kelvin’s circulation theorem-Interaction of vortices	1
2.3	Irrotational Flow Theory: Application of complex variables	1
2.4	Source, Sink, Doublet- Flow at a wall angle	1
2.5	Flow past a circular cylinder with circulation- Forces on 2D body	1
2.6	Exact Solutions of N-S equations: Plane Couette flow and Poiseuille flow-; Hagen -Poiseuille flow	2
2.7	Exact Solutions of N-S equations: Steady flow between concentric cylinders, axisymmetric flows	1
2.8	Impulsively started plates: Similarity solutions; Numerical problems	1
Module 3		**(9 Hours)**
3.1	Boundary Layer Approximations- Measures of boundary layer thickness- displacement and momentum thickness	2
3.2	Blasius Solution, Falkner Skan Solution	2
3.3	Momentum Integral equations, Effect of Pressure gradient	1
3.4	Separation, Sport ball dynamics; Numerical Problems	1
3.5	Theory of Instability: method of normal modes, Orr-Sommerfield equation (Theory only)	2
3.6	Types of Instability: Benard Cells, K-H instability	1

Module 4		**(8 Hours)**
4.1	Introduction to Compressible flows- Speed of Sound- Basic equation for 1 D flow	2
4.2	Stagnation and static properties, Area-Velocity relationship in	2
4.3	Nozzles: mass flow rate, compressible flows in C-D nozzles Geometric choking.	2
4.4	Fanno flow: Effect of friction in constant area ducts- property relationships; Friction choking	2
Module 5		**(8 Hours)**
5.1	Frictionless flow in constant area duct with heat transfer, Rayleigh line, Thermal chocking and its consequences	2
5.2	Standing normal shocks– Fundamental relations-R-H equations-Stationary normal shock waves in C-D Nozzles; Numerical problems	2
5.3	Oblique Shocks: Fundamental relations, θ-β-M diagram.	2
5.4	Shock Reflection and Intersections- Shock tube	2

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. What is the difference between stream function and velocity potential? Explain their significance in fluid flow analysis.
2. Explain the concept of material acceleration in the Eulerian description of fluid motion.

Course Outcome 2 (CO2):

1. What is Kelvin's circulation theorem, and what does it imply for inviscid flows?
2. Explain the significance of a source, sink, and doublet in potential flow theory.

Course Outcome 3 (CO3):

1. What is boundary layer separation, and how does it affect drag on a body?
2. Define momentum thickness and explain its significance in boundary layer theory.

Course Outcome 4 (CO4):

1. Explain the Fanno line and its representation on an h-s (enthalpy-entropy) diagram.
2. What is the sonic condition in a compressible flow, and how is it related to Mach number?

Course Outcome 5 (CO5):

1. What is a Rayleigh flow, and how does heat addition affect Mach number?
2. How does pressure change across a normal shock wave, and why does it happen?

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FOURTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: **B24MEH42**

Course Name: **ADVANCED FLUID MECHANICS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Differentiate between the Lagrangian and Eulerian approaches in fluid mechanics with an example.
2. Derive the differential form of the mass conservation equation for an incompressible flow.
3. State Kelvin's circulation theorem and explain its significance in vortex dynamics.
4. Define a doublet and describe its role in the flow past a circular cylinder.
5. Explain the concept of boundary layer thickness and its different measures.
6. What is the Blasius solution, and how does it apply to boundary layer flow over a flat plate?
7. Derive an expression for the speed of sound in an ideal gas.
8. Explain the concept of friction choking in Fanno flow and its effect on flow properties.
9. What is thermal choking in Rayleigh flow, and how does it affect the flow?
10. Define a normal shock wave and explain how it affects pressure, temperature, and velocity.

PART B

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

Module 1

11. The velocity field in a flow field is given by $\bar{V} = \mathbf{33}xy^2\,\hat{\imath} + \mathbf{22}x\boldsymbol{j} + (\mathbf{22}zy + \mathbf{33}t)\hat{k}$. Find the magnitude and directions of (i) translational velocity, (ii) Rotational Velocity and (iii) vorticity of the fluid element at position (*1,2,1*) and time *t =3*. (14)

OR

12. Write down the general form of the Navier-Stokes equation for a three-dimensional unsteady viscous compressible flow in a gravitational field. Simplify the equation for steady incompressible irrotational flows. (14)

Module 2

13. Oil flows between two parallel plates, one of which is at rest and the other moves with a velocity *U*.

    a. If the pressure is decreasing in the flow direction at a rate of 10 Pa/m, the dynamic viscosity is 0.05 kg/m s, the spacing of the horizontal plate is 0.04 m and the volumetric flow (Q) per unit width is 0.03 m^2/s, what is the velocity *U*? (10)

    b. Calculate *U* if the pressure is increasing at a rate of 5 Pa/m, in the direction of flow. (4)

OR

14. Derive the velocity potential ϕ and stream function ψ for a doublet placed at the origin in a uniform flow of velocity U in the x-direction. (14)

Module 3

15. Water of kinematic viscosity $\upsilon = 1 \times 10^{-6}\ m^2/s$ is flowing steadily over a smooth flat plate at zero angle of attack with a velocity 1.6 m/s. The length of the plate is 0.3 m. Calculate (a) the thickness of the boundary layer at 15 cm from the leading edge. (b) the rate of growth of the boundary layer at 15 cm from the leading edge of the plate. Assume a parabolic velocity profile. (14)

OR

16. Explain how bowlers employ separation phenomena in a cricket game and how trajectories of sports balls are determined by boundary layer separation. How the same separation phenomena are detrimental in rocket propulsion systems? (14)

Module 4

17. Compressed air is discharged through the converging nozzle as shown in figure 2. The tank pressure is 500 kPa and local atmospheric pressure is 101 kPa. The inlet area of the nozzle is 100 cm^2; the exit area is 34 cm^2. Find the force of the air on the nozzle, assuming the air to behave as a perfect gas with constant γ=1.4. Take the temperature in the tank to be 300 K. You may assume that the nozzle is choked and isentropic flow. (14)

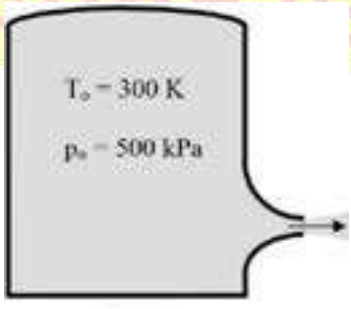


Figure 2

OR

18. Derive the governing equations for adiabatic flow in a constant-area duct with friction using the principles of conservation of mass, momentum, and energy. Discuss the significance of the Fanno line and explain the concept of friction choking. (14)

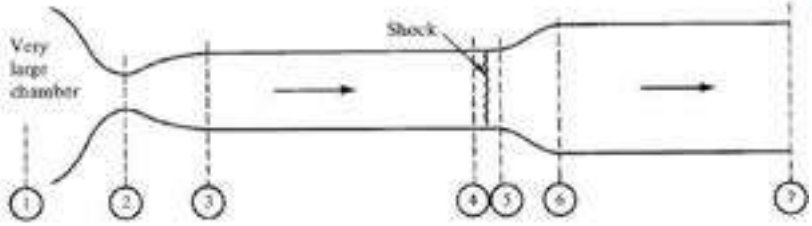
Module 5

19. (a) Explain how thermal chocking happens in flow through varying area duct with the support of property diagrams. (7)

    (b). Derive Rankine -Hugoniot equations for a normal shock. (7)

OR

20. There is no friction in the system shown in the figure below except in the constant-area ducts from sections 3 to 4 and from 6 to 7. Sketch the T –s diagram for the entire system. Assume adiabatic flow throughout the system. (14)



KNOWLEDGE IS POWER

B24MEH43	ADVANCED ENGINEERING MATERIALS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course aims to impart the students a solid comprehension of the engineering materials. By bridging theory and application, students learn to tackle real-world challenges using reasoned assumptions. Emphasizing the key factors that govern the design and selection of materials for use in advanced engineering applications, as well as their processing, properties, and stability. This course aims to empower students with the knowledge of materials used for specific applications and their characteristics.

Prerequisite

Nil

Course Outcomes

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

CO 1	Interpret the effect of microstructure variation in mechanical properties of Non-Ferrous materials. (Cognitive Knowledge Level: Understand)
CO 2	Apply the microstructural parameter in the selection of high-temperature materials. (Cognitive Knowledge Level: Apply)
CO 3	Identify suitable materials for solar energy conversion and shape memory effects. (Cognitive Knowledge Level: Apply)
CO 4	Develop composite material for engineering applications. (Cognitive Knowledge Level: Apply)
CO 5	Select biocompatible material for implant application. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	10	10	20
Understand	60	30	20
Apply	30	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	: 10 marks
Self-Study (Quiz/ Seminar/ Microproject/Analytical Assignments)	: 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

KNOWLEDGE IS POWER

SYLLABUS

MODULE 1 (10 hours)

Non-ferrous metals: Introduction to non-ferrous metals & their alloys: Aluminium Alloys - Classification of Aluminum Alloys, Non-heat treatable Wrought Aluminum Alloys, heat treatable Wrought Aluminum Alloys, Cast Aluminum Alloys with their Phase Diagrams, Compositions, heat treatments, properties and applications. Copper Alloys - Copper, Brass and Bronze Phase Diagrams, Compositions, heat treatments, properties and applications. Magnesium Alloys - Classification of Magnesium Alloys, Wrought Magnesium Alloys, Cast Magnesium Alloys with their Phase Diagrams, Compositions, heat treatments, properties and applications.

MODULE 2 (9 hours)

High temperature materials: Factors influencing functional life of components at elevated temperatures, definition of creep curve, various stages of creep, metallurgical factors influencing various stages, effect of stress, temperature and strain rate. Metals for high temperature service, Ti and Zr alloys, Iron base, nickel base and cobalt base superalloys, composition control, solid solution strengthening, precipitation hardening by gamma prime, grain boundary strengthening, TCP phase - embrittlement, solidification of single crystals, production, properties and applications.

MODULE 3 (8 hours)

Materials for Renewable energy conversion: Photovoltaics - Silicon (Si) solar cells, Crystalline/ Semicrystalline/

Amorphous Si solar cells, thin film solar cells. Photoelectrochemical cells – Semiconductor electrochemistry - Photoelectrolysis, photochemical cells, photocatalysis, Mechanism- electron transfer: Factors affecting electron transfer. Efficiency, limiting factors.

Shape Memory Materials: Shape Memory Alloys (SMA), Shape memory effect, Superelasticity or Pseudoelasticity, Phase Transformation phenomenon in SMAs, Training and stability of SMA, Heating Methods of temperature induced SMA, Types of Shape Memory Alloys, One-way shape memory Alloys, Two-way shape memory, Effect of Thermo-Mechanical Treatments, Effects of Aging, Effect of Grain Size, Effect of Deviation from Equiatomic Stoichiometry, Effect of Additive elements, Effect of Precipitation, Potential Applications, Advantages of SMA materials.

MODULE 4 (9 hours)

Composite materials: Introduction to Composites, function of the matrix and reinforcement in composites.

Classification: polymer matrix composites, metal matrix composites, ceramic matrix composites. Manufacturing Methods: Polymer Matrix Composites-Thermoset Composite manufacturing- Layup processes, Spray-up process, Filament winding; Thermoplastic Composite manufacturing- Film Stacking, Diaphragm Forming, Thermoplastic Tape Laying. Metal Matrix Composites- Solid state methods- hot isostatic pressing (HIP), Foil diffusion bonding. Liquid state methods- Pressure infiltration, Dispersion Processes. Ceramic matrix composites- sintering, CVD.

MODULE 5 (9 hours)

Biomaterials: Introduction and importance of biomaterials; Types of biomaterials: Metallic, ceramic, polymeric and composite biomaterials. Classification according to physiological response of biomaterials: bioinert, bioactive and bioresorbable biomaterials, Governing Factors of Biomaterials, Surface modifications; Surface analysis, In Vitro and in vivo assessment of tissue compatibility.

Text Books

1. William F. Smith, "Structure and Properties of Engineering Alloys", 2nd Edition, McGraw-Hill.
2. Ajit Behera, "Text Book: Advanced Materials", 1st edition, Springer Nature.

Reference Books

1. R. E. Smallman & R. J. Bishop, "Modern Physical Metallurgy and Materials Engineering Science, process, applications", 6th Edition, Butterworth-Heinemann.
2. Matthew J. Donachie & Stephen J. Donachie, "SUPERALLOYS A Technical Guide", 2nd Edition, ASM International.
3. Juan M. Coronado, Fernando Fresno, María D. Hernández-Alonso and Raquel Portela, "Design of Advanced Photocatalytic Materials for Energy and Environmental Applications", Springer.
4. Krishan K. Chawla, "Composite Materials Science and Engineering", 3rd Edition, Springer.
5. J.B. Park and J.D. Bronzino, "Biomaterials: Principles and Applications", CRC Press.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**10**
1.1	Introduction to non-ferrous metals & their alloys.	1
1.2	Aluminum Alloys - Classification of Aluminum Alloys, Non-heat treatable Wrought Aluminum Alloys, heat treatable Wrought Aluminum Alloys, Cast Aluminum Alloys with their Phase Diagrams.	1
1.3	Aluminum Alloys - Compositions, heat treatments, properties and applications.	2
1.4	Copper Alloys - Copper, Brass and Bronze Phase Diagrams.	1
1.5	Copper Alloys - Compositions, heat treatments, properties and applications.	2
1.6	Magnesium Alloys - Classification of Magnesium Alloys, Wrought Magnesium Alloys, Cast Magnesium Alloys with their Phase Diagrams.	1

1.7	Magnesium Alloys - Compositions, heat treatments, properties and applications.	2
	Module 2	**9**
2.1	Factors influencing functional life of components at elevated temperatures,	1
2.2	Definition of creep curve, various stages of creep, metallurgical factors influencing various stages, effect of stress, temperature and strain rate.	2
2.3	Metals for high temperature service, Ti and Zr alloys, Iron base, nickel base and cobalt base superalloys	2
2.4	composition control, solid solution strengthening, precipitation hardening by gamma prime, grain boundary strengthening, TCP phase - embrittlement,	3
2.5	solidification of single crystals, production, properties and applications.	1
	Module 3	**8**
3.1	**Materials for Renewable energy conversion:** Photovoltaics - Silicon (Si) solar cells, Crystalline/ Semicrystalline/ Amorphous Si solar cells, thin film solar cells.	1
3.2	Photoelectrochemical cells – Semiconductor electrochemistry - Photoelectrolysis, photochemical cells.	1
3.3	phootcatalysis, Mechanism- electron transfer: Factors affecting electron transfer. Efficiency, limiting factors.	2
3.4	**Shape Memory Materials**: Shape Memory Alloys (SMA), Shape memory effect, Superelasticity or Pseudoelasticity, Phase Transformation phenomenon in SMAs.	1
3.5	Training and stability of SMA, Heating Methods of temperature induced SMA,	1
3.6	Types of Shape Memory Alloys, One-way shape memory Alloys, Two-way shape memory,	1
3.7	Effect of Thermo-Mechanical Treatments, Effects of Aging, Effect of Grain Size, Effect of Deviation from Equiatomic Stoichiometry, Effect of Additive elements, Effect of Precipitation, Potential Applications, Advantages of SMA materials.	1
	Module 4	**9**
4.1	**Composite materials**: Introduction to Composites, function of the matrix and reinforcement in composites.	1
4.2	Classification: polymer matrix composites, metal matrix composites, ceramic matrix composites.	1
4.3	Manufacturing Methods: Polymer Matrix Composites-Thermoset Composite manufacturing- Layup processes, Sprayup process, Filament winding;	1
4.4	Thermoplastic Composite manufacturing- Film Stacking, Diaphragm Forming, Thermoplastic Tape Laying.	2
4.5	Metal Matrix Composites- Solid state methods- hot isostatic pressing (HIP), Foil diffusion bonding.	2

4.6	Liquid state methods- Pressure infiltration, Dispersion Processes. Ceramic matrix composites- sintering, CVD.	2
	Module 5	**9**
5.1	**Biomaterials:** Introduction and importance of biomaterials; Types of biomaterials: Metallic, ceramic, polymeric and composite biomaterials.	3
5.2	Classification according to physiological response of biomaterials: bioinert, bioactive and bioresorbable biomaterials,	3
5.3	Governing Factors of Biomaterials, Surface modifications; Surface analysis, In Vitro and in vivo assessment of tissue compatibility.	3
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. What are the advantages of using non-ferrous metals in industrial applications?
2. How are non-ferrous metals classified based on their properties and applications?
3. What are the main differences between wrought and cast aluminum alloys?
4. How does the addition of zinc affect the properties of copper in brass alloys?
5. How do magnesium alloys compare with aluminum alloys in terms of strength and weight?
6. Evaluate the applications of copper alloys in electrical and marine industries. Why is copper preferred for electrical applications?
7. Explain the significance of heat treatment in magnesium alloys. What challenges are faced in processing magnesium alloys?

Course Outcome 2 (CO2):

1. What are the key factors that influence the functional life of components operating at high temperatures?
2. What is thermal fatigue, and why is it important for high-temperature materials?
3. Explain the effect of applied stress on creep deformation.
4. How does oxidation and corrosion affect high-temperature materials?
5. What is the role of solid solution strengthening in high-temperature alloys?
6. Explain the role of Topologically Close-Packed (TCP) phases in the embrittlement of superalloys.
7. What are the challenges associated with solidification of single-crystal superalloys?

Course Outcome 3 (CO3):

1. What are the limitations of silicon-based solar cells, and how can they be improved?
2. . How does photocatalysis differ from photochemical cells?
3. What is the effect of grain size on the properties of SMAs?
4. What are the advantages and limitations of shape memory alloys?
5. How do superelasticity and pseudoelasticity differ from the shape memory effect?
6. How does phase transformation contribute to the shape memory behavior?
7. What are the major factors affecting electron transfer in PEC systems?

Course Outcome 4 (CO4):

1. What role does the reinforcement play in composite materials?
2. How do composites achieve superior mechanical properties compared to individual materials?
3. What are the advantages of polymer matrix composites (PMCs)?
4. What is filament winding, and where is it commonly used?
5. How does the pressure infiltration method work for liquid-state MMC processing?
6. What are the main manufacturing methods for ceramic matrix composites?
7. How does the hand layup process work in thermoset composite manufacturing?

Course Outcome 5 (CO5):

1. Define biomaterials and mention their importance in medical applications.
2. What are the governing factors of biomaterials?
3. List any two advantages and disadvantages of metallic biomaterials.
4. What is in vivo testing of biomaterials? How is it different from in vitro testing?
5. What are the techniques used for surface analysis of biomaterials?
6. What are bioresorbable biomaterials? How do they work in the body?
7. What are composite biomaterials, and why are they advantageous?

KNOWLEDGE IS POWER

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name: .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FOURT SEMESTER B TECH DEGREE EXAMINATION, APRIL 2026

Course Code: **B24MEH43**

Course Name: **ADVANCED ENGINEERING MATERIALS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. How are aluminum alloys classified?
2. What are the key properties of pure copper?
3. Explain the role of microstructural stability in determining the lifespan of high-temperature components.
4. What are the metallurgical factors that influence the different stages of creep?
5. What factors affect the efficiency of photovoltaic (PV) cells?
6. What is the shape memory effect, and how does it work in SMAs?
7. What are the main functions of the matrix in a composite material?
8. How does hot isostatic pressing (HIP) work in MMC manufacturing?
9. Differentiate between bioinert, bioactive, and bioresorbable biomaterials.
10. Explain the difference between in vitro and in vivo assessment of tissue compatibility.

PART B

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

Module 1

11. Discuss the role of heat treatment in aluminum alloys. Explain the different heat treatment processes used and their effects on mechanical properties. (14 marks)

OR

12. Magnesium alloys are highly susceptible to corrosion. Discuss the factors affecting their corrosion resistance and the methods used to improve it. (14marks)

Module 2

13. Define a creep curve and explain its significance. (14marks)

OR

14. Describe the production methods used for single-crystal superalloys. (14marks)

Module 3

15. Describe the mechanism of photoelectrochemical (PEC) cells and their role in renewable energy conversion. What are the major challenges in improving their efficiency? (14marks)

OR

16. Evaluate the role of additive elements and precipitation in modifying the mechanical and thermal properties of SMAs. (14marks)

Module 4

17. How does sintering help in ceramic matrix composite fabrication? (14marks)

OR

18. What is chemical vapor deposition (CVD), and how is it used in CMC manufacturing (14marks)

Module 5

19. Discuss the importance of surface modifications in biomaterials. Explain different surface modification techniques and their applications. (14 marks)

OR

20. What are the common tests used to assess biocompatibility? (14 marks)

KNOWLEDGE IS POWER

MAR ATHANASIUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution
Kothamangalam, Kerala, India

B.TECH MECHANICAL ENGINEERING

SEMESTER 5

SYLLABUS

SEMESTER 5

SLOT	COURSE NO.	COURSES	L-T-P-S	HOURS	CREDIT
A	B24ME3T01	DYNAMICS AND DESIGN OF MACHINES	3-1-0-5	4	4
B	B24ME3T02	THERMAL POWER ENGINEERING	3-1-0-5	4	4
C	B24ME3T03	MANUFACTURING TECHNOLOGY	3-1-0-5	4	4
D	B24ME3T04	ROBOTICS AND AUTOMATION	3-1-0-5	4	4
E	B24ME3T05	INDUSTRIAL AND SYSTEMS ENGINEERING	2-1-0-4	3	3
F	B24ME3P1x	PROGRAMME ELECTIVE I	2-1-0-4	3	3
G	B24ME3L06	ROBOTICS AND AUTOMATION LAB	0-0-3-2	3	2
H	B24ME3L07	THERMAL POWER LAB	0-0-3-2	3	2
M	B24MEM5x	MINOR	3-1-0-5	4	4
N	B24MEH5x	HONOURS	3-1-0-5	4	4
			TOTAL*	**36**	**26**

PROGRAMME ELECTIVE I

B24ME3P11	OPERATIONS MANAGEMENT
B24ME3P12	ORGANIZATIONAL BEHAVIOUR & HUMAN RESOURCES MANAGEMENT
B24ME3P13	STRATEGIC MARKETING MANAGEMENT
B24ME3P14	OPERATIONS RESEARCH
B24ME3P15	OBJECT ORIENTED PROGRAMMING
B24ME3P16	DATA ANALYTICS FOR ENGINEERS
B24ME3P17	BASICS OF ARDUINO PROGRAMMING

B24ME3T01	DYNAMICS AND DESIGN OF MACHINES	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course focuses on important topics of dynamics of machinery and design of machine elements. It covers the topics namely forces in four bar mechanisms, design of flywheels, welded joints, riveted joints and spring. Design of machine elements for impact, shock and fatigue loading are covered in the syllabus. Analysis of free and forced vibration of single degree of freedom systems and a brief introduction about free vibration of two degree of freedom systems is also included.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the procedure for engine force analysis and interpret turning moment diagrams. (Cognitive Knowledge Level: Understand)
CO 2	Explain the concepts of free and forced vibrations in single degree of freedom systems. (Cognitive Knowledge Level: Understand)
CO 3	Determine the natural frequencies of two degree of freedom vibrating systems and calculate stresses in structural members subjected to combined loading. (Cognitive Knowledge Level: Apply)
CO 4	Design machine elements subjected to fatigue loading and design riveted joints based on given loading conditions (Cognitive Knowledge Level: Apply)
CO 5	Design welded joints and close-coiled helical compression springs to meet specified functional requirements. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember			
Understand	40	10	10
Apply	60	30	30
Analyse		60	60
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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Dynamic Force Analysis and Flywheel Design (8 hours)

Dynamic force analysis- D' Alembert's principle –four bar mechanism- engine force analysis (reciprocating engines)- piston side thrust-connecting rod force-piston effort- dynamic force analysis considering mass of the connecting rod-analytical method.

Flywheels-turning moment diagrams for four stroke internal combustion engine and multi cylinder engines-coefficient of fluctuation of speed-coefficient of fluctuation of energy design of flywheels.

MODULE 2: Introduction to Vibration (12 hours)

Introduction- free vibration of single degree undamped systems- natural frequency-energy method- Newton's second law (free body diagram)-damped systems- logarithmic decrement. Forced vibration-single degree of freedom systems-harmonic excitation-vibration isolation transmissibility-whirling of shafts. Introduction to 2D of freedom system, natural frequency and mode shape.

MODULE 3: Introduction to Machine Design (6 hours)

Introduction to design-definition, steps in the design process, materials and their properties elastic and plastic behaviour of metals, ductile and brittle behaviour, shear, bending and torsional stresses, combined stresses, stress concentration factor.

MODULE 4: Fatigue, Impact Loading, and Design of Riveted Joints (9 hours)

Shock and impact loads- fatigue loading- Gerber, Goodman and Soderberg criteria, endurance limit stress, factors affecting endurance limit, factor of safety. Deign of riveted joints- material for rivets, modes of failure, efficiency of joint, design of boiler and tank joints, structural joints.

MODULE 5: Design of Welded Joints and Mechanical Springs (10 hours)

Design of welded joints-welding symbols, stresses in fillet and butt welds, Butt joint in tension, fillet weld in tension, fillet joint under torsion, fillet weld under bending, eccentrically loaded welds.

Springs- classification, spring materials, stresses and deflection of helical springs, axial loading, curvature effect, resilience, static and fatigue loading, surge in spring, critical frequency, concentric springs, end construction

Text Books

1. Ballaney, P. L. Theory of machines and mechanisms. Khanna Publishers.
2. Rattan S S, Theory of Machines, Tata McGraw-Hill Education.
3. Bhandari V B, Design of Machine Elements, Tata McGraw-Hill Education.

Design Data Books (permitted for reference in the university examination)

1. Mahadevan, K., and K. Balaveera Reddy. Design Data Handbook; Mechanical Engineers in SI and Metric Units. CBS Publishers & Distributors, New Delhi.
2. Narayana Iyengar B.R & Lingaiah K, Machine Design Data Handbook, Tata McGraw Hill/Suma Publications.

3. PSG Design Data, DPV Printers, Coimbatore.

Reference Books

1. Charles E Wilson and J Peter Sadler, Kinematics and Dynamics of Machinery, Tata McGraw-Hill Education.
2. Amithabha Ghosh and Asok Kumar Malik, Theory of Mechanisms and Machines, East West Press.
3. Robert L Norton, Design of Machinery, Tata Mc Graw-Hill.
4. P C Sharma and D K Aggarwal, Machine Design, S K Kataria & Sons

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**8**
1.1	Dynamic force analysis-D'Alembert's principle–Four bar mechanism	2
1.2	Engine force analysis (reciprocating engines)- piston side thrust-connecting rod force-piston effort- dynamic force analysis considering mass of the connecting rod-analytical method.	2
1.3	Flywheels, turning moment diagrams – four stroke internal combustion engines and multi cylinder engines	2
1.4	Coefficient of fluctuation of speed-coefficient of fluctuation of energy-design of flywheels	2
	Module 2	**12**
2.1	Introduction- free vibration of single degree undamped systems-natural frequency-energy method	2
2.2	Newton's second law (free body diagram)-damped systems-logarithmic decrement.	2
2.3	Forced vibration-single degree of freedom systems	2
2.4	Harmonic excitation-vibration isolation-transmissibility-	2
2.5	Whirling of shafts.	1
2.6	Introduction to two-degree-of-freedom systems, natural frequencies and mode shapes.	3
3.1	**Module 3**	**6**
3.2	Introduction to design-definition, steps in design process. materials and their properties	2
3.3	Elastic and plastic behaviour of metals, Ductile and brittle behaviour	1
3.4	Shear, bending and torsional stresses, combined stresses, stress concentration factor.	3
	Module 4	**9**
4.1	Shock and Impact loads, fatigue loading	2
4.2	Gerber, Goodman and Soderberg criteria, endurance limit stress,	2
4.3	Factors affecting endurance limit, factor of safety.	1

4.4	Deign of riveted joints- material for rivets, modes of failure, efficiency of joint	2
4.5	Design of boiler and tank joints, structural joints.	2
	Module 5	**10**
5.1	Design of welded joints-welding symbols, stresses in fillet and butt welds, butt joint in tension, fillet weld in tension,	3
5.2	Fillet joint under torsion, fillet weld under bending, eccentrically loaded welds.	3
5.3	Springs-classification, spring materials, stresses and deflection of helical springs, axial loading, curvature effect, resilience, static and fatigue loading,	2
5.4	surge in spring, critical frequency, concentric springs, end construction	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain D'Alembert's principle.
2. Determine analytically the forces such as piston effort, force in the connecting rod and side thrust on the cylinder walls of a reciprocating engine.
3. Draw the turning moment diagram of IC engine.
4. Derive an expression for the coefficient of fluctuation of energy.
5. Derive an expression relating the stress in a flywheel and its linear speed.

Course Outcome 2 (CO2):

1. Explain the energy method and Newton's method to determine the natural frequencies of a single degree of freedom system.
2. Derive an expression for the logarithmic decrement.
3. Find the forced response of a damped single degree of freedom vibrating system subjected to a harmonic excitation.
4. Distinguish between motion transmissibility and force transmissibility.
5. What is whirling? Derive an expression for the critical speed of a shaft.
6. Find the natural frequencies and mode shapes of a two degree freedom vibrating system.
7. What do you mean by eigen values and eigen vectors of a multi degree freedom vibrating system?

Course Outcome 3 (CO3):

1. What are the steps in the design process?
2. Define stress concentration factor. How can we minimize it?

Course Outcome 4 (CO4):

1. Explain Goodman's criterion.
2. Explain Soderberg's criterion.
3. Define endurance limit and factor of safety.
4. Derive an expression for the impact stress due to a freely falling body.
5. Describe the modes of failure of a riveted joint.
6. What are the different efficiencies of a riveted joint?
7. Classify the riveted joints.

Course Outcome 5 (CO5)

1. What are the different types of welded joint?
2. Describe AWS welding symbols with neat sketches.
3. Determine the weld size of a joint subjected to axial, bending and twisting loads.
4. Derive an expression for the shear stress in the spring wire.
5. Derive an expression for the impact stress due to a freely falling body.
6. Describe the modes of failure of a riveted joint.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

FIFTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: **B24ME3T01**

Course Name: **DYNAMICS AND DESIGN OF MACHINES**

Max. Marks: 100 Duration: 3 hours

(Use of Design Databook is permitted in the examination hall)

PART A

Answer all questions. Each question carries 3 marks.

1 Distinguish between crank effort and piston effort.

2 Discuss the turning moment diagram for a four-stroke internal combustion engine.

3 Derive an expression to find the natural frequency of free longitudinal vibration of a spring–mass system.

4 What is vibration isolation, and how is it implemented for heavy machines?

5 What factors in a design lead to stress concentration?

6 What factors should be considered while selecting materials for engineering purposes?

7 Explain the significance of the S–N diagram in the design of machine components.

8 What are the different modes of failure of riveted joints?

9 Explain any three weld symbols.

10 List the requirements of spring materials.

PART B

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

Module 1

11 A steam engine 200 mm bore and 300 mm stroke has a connecting rod 625 mm long. The mass of the reciprocating parts is 15 kg and the speed is 250 rpm. When the crank is 300 to the inner dead centre and moving outwards, the difference in steam pressure is 840 kN/m2. Determine

1. The force on the crank shaft bearing
2. The torque acting on the frame (14 marks)

OR

12 A shaft fitted with a flywheel rotates at 250 rpm and drives a machine. The torque of machine varies in a cyclic manner over a period of 3 revolutions. The torque rises from 750 Nm to 3000 Nm uniformly during 1/2 revolution and remains constant for the following revolution. It then falls uniformly to 750 Nm during the next 1/2 revolution and remains constant for one revolution, the cycle being repeated thereafter. Determine the power required to drive the machine and percentage fluctuation in speed, if the driving torque applied to the shaft is constant and the mass of the flywheel is500 kg with radius of gyration of 600mm

(14 marks)

Module 2

13 a. Discuss briefly with neat sketches the longitudinal, transverse and torsional free vibrations. (7 marks)

b. A vibrating system consists of a mass of 10kg, spring stiffness 12N/mm and a dash pot of damping coefficient of 0.06 N/mm/sec. Determine

i. Damping factor,
ii. Logarithmic decrement
iii. Ratio of the two consecutive amplitudes (7 marks)

OR

14 a. What is meant by magnification factor? (5 marks)

b. A mass of 10 kg is suspended from one end of a helical spring; the other end is fixed. The stiffness of spring is 10 N/mm. The viscous damping causes the amplitude to decrease to 1/10th of initial value in four complete oscillations. If a periodic force of 150 cos 50t N is applied at the mass, determine the amplitude and phase angle of the resulting motion. What is its value at resonance?

(9 marks)

Module 3

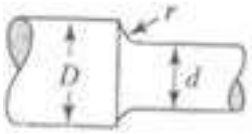
15 a. Mention the different methods that can be adopted to reduce stress concentration (5 marks)

b. Explain in detail the plastic and elastic behaviour in metals. (9 marks)

OR

16 a. Describe briefly the general design procedure to solve a design problem. (5 marks)

b. Find the maximum stress developed in a stepped shaft subjected to a twisting moment of 100 Nm as shown in Fig.2 What would be the maximum stress developed if a bending moment of 150 Nm is applied.



r = 6 mm
d = 30 mm
D = 40 mm.

(9 marks)

Module 4

17 A circular bar of 500 mm length is supported freely at its two ends. It is acted upon by a central concentrated cyclic load having a minimum value of 20 kN and a maximum value of 50 kN. Determine the diameter of bar by taking a factor of safety 1.5, size effect of 0.85, surface finish factor of 0.9. The material properties of bar is given by ultimate strength of 650 MPa, yield strength of 500 MPa and endurance strength of 350 MPa.

(14 marks)

OR

18 Two lengths of mild steel tie rod having width 200 mm and thickness 12.5 mm are to be connected by means of a butt joint with double cover plates of equal thickness. Design the joint if the permissible stresses are 80 MPa in tension, 65 MPa in shear, and 160MPa in crushing.

(14 marks)

Module 5

19 a. Describe about Weld reinforcement. (5 marks)

b. A steel plate strip of 150 mm width and 10 mm thickness is to be welded to another plate by a single transverse weld and a double parallel fillet weld. The strip is required to carry an axial load. The maximum tensile and shear stresses are 70 MPa and 56 MPa respectively. Calculate the length of the fillet weld, if the joint is subjected to static loading condition.

(9 marks)

OR

20 a. Derive an expression for the deflection in the spring wire. (5 marks)

b. Design a helical compression spring for a maximum load of 1000N for a deflection of 20 mm using spring index as 5. Shear stress for spring wire is 420 MPa and Modulus of rigidity is 84 GPa. (9 marks)

B24ME3T02	THERMAL POWER ENGINEERING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course introduces the principles and applications of thermal energy conversion systems used in modern power generation. It covers steam power cycles, gas turbines, internal combustion engines, and power plant components with emphasis on performance analysis, efficiency enhancement, and practical relevance.

Prerequisites

Engineering Thermodynamics

Course Outcomes

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

CO 1	Understand steam properties and Rankine cycles to interpret boiler performance and overall cycle efficiency. (Cognitive Knowledge Level: Understand)
CO 2	Apply nozzle flow relations and turbine velocity diagrams to determine mass flow rate, work done, and stage efficiencies. (Cognitive Knowledge Level: Apply)
CO 3	Apply the principles of Brayton and combined cycles to analyse performance and improvements through regeneration, intercooling, and reheating. (Cognitive Knowledge Level: Apply)
CO 4	Understand combustion characteristics and performance testing of IC engines to compute efficiency parameters and assess engine behaviour. (Cognitive Knowledge Level: Understand)
CO 5	Understand the layout, auxiliary systems, performance indices, and economic considerations of modern thermal power plants. (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									
CO 2	3	3	2	1							
CO 3	3	3	2	1		1					
CO 4	3	2		1		1					
CO 5	3	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Steam Engineering (9 hours)

Introduction to steam properties and charts, Rankine cycle: Representation on T–s and h–s diagrams, Analysis, Rankine cycle modifications – reheat, regeneration, binary vapour and combined cycles.

Boilers: Classification – fire-tube and water-tube types; Cochran, Babcock & Wilcox, Benson boilers, Ultra super critical boilers, Boiler accessories – economizer, superheater, air preheater, Boiler performance – evaporation ratio, boiler efficiency, heat balance.

MODULE 2: Steam Nozzles and Steam Turbines (9 hours)

Steam Nozzles: Types – Convergent, convergent–divergent; isentropic flow, friction and supersaturation effects, critical pressure ratio, choking, mass flow rate, nozzle efficiency.

Steam Turbines: Classifications, velocity diagrams, work done, stage and blade efficiency, degree of reaction, specific steam consumption, overall efficiency. Compounding of turbines – velocity, pressure and pressure-velocity compounding, Condensing Turbines, Governing of turbines, Turbine losses and performance parameters.

MODULE 3: Gas Turbines (9 hours)

Classification, Thermodynamic analysis of closed cycle gas turbine, Ideal Brayton cycle, P-v and T-s diagram, thermal efficiency. Effect of compressor and turbine efficiencies. Optimum pressure ratio for maximum specific work output with and without considering machine efficiencies. Actual Cycles. Analysis of open cycle gas turbine, Improvements of the basic gas turbine cycles-regeneration, intercooling and reheating-cycle efficiency and work output-Condition for minimum compressor work and maximum turbine work. Combustion chambers for gas turbines.

Combined Cycles: Gas–steam combined systems layouts, cogeneration, and waste heat recovery (Theory only)

MODULE 4: I C Engines (9 hours)

Combustion in I.C. Engines- Combustion phenomena in S.I. engines; Ignition limits, stages of combustion in S.I. Engines, Ignition lag, auto ignition, Knocking; effects of engine variables on knocking; pre-ignition; Combustion in C.I. Engines; delay period; variables affecting delay period; detonation in C.I. engines. Rating of fuels.

Performance Testing of I C Engines- Indicator diagram, mean effective pressure. Torque, Engine power- BHP, IHP. Engine efficiency - mechanical efficiency, volumetric efficiency, thermal efficiency, relative efficiency, Specific fuel consumption. Morse test, Heat balance test and Retardation test.

MODULE 5: Power Plant Engineering (9 hours)

Schematic diagram of modern steam power plant, Working, feed pump, safety valves, steam stop valve, electrostatic precipitator, steam traps and its types, Fuel handling system- Coal handling, Pulverization of coal – Ball Mill, Ash Handling System- Types of ash (Bottom Ash & Fly Ash), Feed Water Treatment, Parameters of feed water (Total Hardness, pH, Total Dissolved Solid (TDS)), Fluidized Bed Combustion (FBC), Power plant performance indices – heat rate, load factor, capacity factor, thermal efficiency, Basic power plant economics – cost of generation, maintenance, and reliability.

Text Books

1. Rudramoorthy, *Thermal Engineering*, McGraw Hill Education India.
2. Rajput R.K., *Thermal Engineering*, Laxmi publications.
3. Ganasen V., Gas Turbines, McGraw Hill Education.
4. Mathur & Sharma, *Internal Combustion Engines*, Dhanpat Rai Publications.
5. Rajput R.K., *Power Plant Engineering*, Laxmi publications.

Reference Books

1. Ballaney P.L., *Thermal Engineering*, Khanna Publishers.
2. Rathore, *Thermal Engineering*, McGraw Hill Education India Private Limited.
3. Sadhu Singh & Sukumar Pati, *Thermal Engineering*, Pearson.
4. Saravanamuttoo & Cohen, *Gas Turbine Theory*, Pearson.
5. John B. Heywood, *Internal Combustion Engine Fundamentals*, McGraw Hill Edn.
6. Nag P.K., *Power Plant Engineering*, Tata McGraw Hill.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**9**
1.1	Introduction to steam properties and charts.	1
1.2	Rankine cycle: Representation on T–s and h–s diagrams, Analysis + Problems	1
1.3	Rankine cycle modifications – reheat, regeneration, binary vapour and combined cycles + Problems	3
1.4	Boilers: Classification – fire-tube and water-tube types; Cochran boiler, Babcock & Wilcox,	1
1.5	Loeffler boilers, ultra super critical boilers.	1
1.6	Boiler mountings and accessories – economizer, superheater, air preheater, feed pumps.	1
1.7	Boiler performance – evaporation ratio, boiler efficiency, heat balance.	1
	Module 2	**9**
2.1	Steam Nozzles: Types, isentropic flow, friction and supersaturation effects	1
2.2	Critical pressure ratio, choking, mass flow rate, nozzle efficiency + Problems	2
2.3	Steam Turbines: Classifications, Velocity diagrams, work done, stage and blade efficiency, degree of reaction, specific steam consumption, overall efficiency+ Problems	4
2.4	Compounding of turbines – velocity, pressure and pressure-velocity	1

	compounding, Condensing turbines.	
2.5	Governing of turbines, Turbine losses and performance parameters	1
	Module 3	**9**
3.1	Gas turbines: Classification, Thermodynamic analysis of closed cycle gas turbine, Ideal Brayton cycle, P-v and T-s diagram, thermal efficiency + Problems	2
3.2	Effect of compressor and turbine efficiencies. Optimum pressure ratio for maximum specific work output with and without considering machine efficiencies, Actual Cycles + Problems	2
3.3	Improvements of the basic gas turbine cycles-regeneration, intercooling and reheating-cycle efficiency and work output + Problems	3
3.4	Condition for minimum compressor work and maximum turbine work. Combustion chambers for gas turbines.	1
3.5	Gas–steam combined systems, layouts, cogeneration, and waste heat recovery. (Theory only)	1
	Module 4	**9**
4.1	Combustion in I.C. Engines- Combustion phenomena in S.I. engines; Ignition limits	1
4.2	Stages of combustion in S.I. Engines, Ignition lag, auto ignition	1
4.3	Knocking; effects of engine variables on knocking; pre-ignition	1
4.4	Combustion in C.I. Engines; delay period; variables affecting delay period; detonation in C.I. engines. Rating of fuels.	2
4.5	Performance Testing of I C Engines- Indicator diagram, mean effective pressure. Torque, Engine power- BHP, IHP. Engine efficiency - mechanical efficiency, volumetric efficiency, thermal efficiency, relative efficiency, Specific fuel consumption.	2
4.6	Morse test, Heat balance test and Retardation test + Problems	2
	Module 5	**9**
5.1	Schematic diagram of modern steam power plant	1
5.2	Working feed pump, electrostatic precipitator, steam traps and its types	2
5.3	Fuel handling system- Coal handling, Pulverization of coal – Ball Mill, Ash Handling System- Types of ash (Bottom Ash & Fly Ash)	2
5.4	Feed Water Treatment- Parameters of feed water (Total Hardness, pH, Total Dissolved Solid (TDS))	1
5.5	Fluidized Bed Combustion (FBC)	1
5.6	Power plant performance indices – heat rate, load factor, capacity factor, thermal efficiency.	1
5.7	Basic power plant economics – cost of generation, maintenance, and reliability.	1
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Draw the T-S diagram of a reheat cycle. Mention two advantages of the reheat cycle
2. An ideal regenerative steam cycle operates with the steam entering the turbine at 30 bar and 500 °C and is exhausted at 0.1 bar. A feed water heater is used, which operates at 5 bar. Calculate (a) the thermal efficiency, (b) specific steam consumption and (c) average temperature of heat addition. Compare these to an ideal Rankine cycle operates between same conditions.
3. With the help of a figure explain the working of a Benson boiler and mention its merits and demerits over other high-pressure boilers.

Course Outcome 2 (CO2):

1. Derive the expression for critical pressure ratio of flow of steam through nozzle.
2. In an impulse turbine, the mean diameter of the blades is 1.05 m and the speed is 3000 rpm. The nozzle angle is 18°, speed ratio is 0.42, and the friction factor is 0.84. The outlet blade angle is to be made 3° less than the inlet angle. The steam flow is 10 kg/s. Draw the velocity diagrams for the blades and calculate (a) the tangential thrust, (b) the axial thrust, (c) the resultant thrust, (d) the power developed, and (e) the blade efficiency.
3. Explain degree of reaction of a steam turbine and derive an expression for it

Course Outcome 3 (CO3):

1. For an ideal Brayton cycle, derive and apply the expression for optimum pressure ratio that gives maximum specific work output**.** Also explain how the optimum pressure ratio is modified when compressor and turbine efficiencies are considered in an actual gas turbine.
2. An open-cycle gas turbine operates with a pressure ratio of 8. The compressor efficiency is 80% and the turbine efficiency is 85%. The air enters the compressor at 300 K, and the maximum cycle temperature is 1400 K. Assuming air as the working fluid, (a) calculate the actual net specific work output, and (b) determine the actual thermal efficiency of the cycle.
3. Using the principles of thermodynamics, apply the conditions for minimum compressor work and maximum turbine work to explain the role of multistage compression with intercooling and multistage expansion with reheating in gas turbine power plants.

Course Outcome 4 (CO4):

1. With help of a p-θ diagram explain stages of CI engine combustion.
2. Discuss about knocking in SI Engine, its causes and effects.
3. The following observations were made during a trial of a single cylinder 4 stroke diesel engine. Cylinder diameter = 20 cm, Stroke = 40 cm, mean effective pressure 6 bar, torque = 407 Nm, Speed = 250 rpm, fuel consumption = 4 kg/h, Calorific value of the fuel = 43 MJ/kg, cooling water flow rate = 4.5 kg/min, air used per kg of fuel = 30 kg, rise in cooling water temperature = 45 ^{o}C, temperature of exhaust gas = 420 ^{0}C, room temperature = 20 ^{0}C, specific heat of exhaust gas = 1 kJ/kg K and specific heat of water = 4.18 kJ/kgK. Find mechanical efficiency, brake thermal efficiency, specific fuel consumption and prepare the heat balance sheet in KJ/hr.

Course Outcome 5 (CO5)

1. Explain the working of a modern coal based steam power plant with the help of neat schematic diagram.
2. Describe the coal handling system of a thermal power plant and explain the working principle of a ball mill used for pulverization of coal.
3. Explain the objectives of feed water treatment in steam power plants and describe the significance of feed water parameters such as total hardness, pH, and total dissolved solids (TDS).

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: **B24ME3T02**

Course Name: **THERMAL POWER ENGINEERING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the Rankine cycle in steam power plants with T-s diagram
2. Discuss how the use of a superheater improves boiler performance.
3. Illustrate the concept of critical pressure ratio in steam nozzles.
4. Discuss the role of degree of reaction in steam turbine operation.
5. Justify the suitability of gas turbines for peak-load power generation.
6. Interpret the effect of compressor efficiency on Brayton cycle performance.
7. Describe the causes of ignition lag in spark ignition engines.
8. Discuss the importance of mean effective pressure in engine performance analysis.
9. Describe the operating principle of an electrostatic precipitator.
10. Discuss the significance of load factor and capacity factor in power plant operation.

PART B

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

Module 1

11 a. Illustrate the Rankine cycle with the help of T–s and h–s diagrams. (5 marks)

b. Discuss the influence of reheating and regeneration on the performance of a steam power plant. (9 marks)

OR

12 a. Classify and compare fire-tube and water-tube boilers with suitable reasons. (4 marks)

b. Illustrate the construction and working of a Babcock and Wilcox boiler with a neat sketch. (5 marks)

c. Discuss boiler efficiency and the significance of heat balance. (5 marks)

Module 2

13 a. Steam expands isentropically through a convergent–divergent nozzle from a pressure of 10 bar and temperature of 300°C to a pressure of 2 bar. Apply steam nozzle relations to calculate: (a) Critical pressure ratio (b) Exit velocity (c) Mass flow rate (Assume suitable steam properties.) (14 marks)

OR

14 a. Construct the velocity diagram of an impulse turbine and apply it to derive the expression for work done per kg of steam. (4 marks)

b. Apply the concepts of blade efficiency and stage efficiency to explain turbine performance. (5 marks)

c. Apply governing methods to explain speed control of steam turbines. (5 marks)

Module 3

15 a. An ideal Brayton cycle operates between temperature limits of 300 K and 1200 K with a pressure ratio of 8. Apply air-standard cycle relations to determine:
a) Thermal efficiency
b) Specific work output. (14 marks)

OR

16 a. An open-cycle gas turbine operates with a pressure ratio of 6. The compressor and turbine efficiencies are 80% and 85% respectively, and the inlet temperature is 300 K. Apply gas turbine performance equations to calculate: (a) Net specific work output (b) Thermal efficiency (c) Effect of intercooling and reheating on work output. (14 marks)

Module 4

17 a. Explain the stages of combustion in spark ignition engines. (7 marks)

b. Explain the phenomenon of knocking in S.I. engines and discuss the effect of engine variables. (7 marks)

OR

18 a. Explain combustion in compression ignition engines, highlighting delay period and detonation. (7 marks)

b. Explain the working principles of Morse test and heat balance test used for engine performance evaluation. (7 marks)

Module 5

19 a. Explain the layout and working of a modern steam power plant with a neat schematic diagram. (7 marks)

b. Explain the working principle of a ball mill type coal pulverizer. (7 marks)

OR

20 a. Explain the coal handling and ash handling systems used in thermal power plants. (4 marks)

b. Explain the difference between bottom ash and fly ash. (5 marks)

c. Explain power plant performance indices such as heat rate, load factor, and thermal efficiency. (5 marks)

B24ME3T03	MANUFACTURING TECHNOLOGY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course introduces students to major manufacturing processes, including casting, welding, forging, rolling, sheet metal operations, and additive manufacturing. Students will gain an understanding of the principles, techniques, applications, defect mechanisms, and quality control practices associated with these processes. By integrating theoretical concepts with real-world industrial relevance, the subject prepares students to analyze, select, and optimize manufacturing processes for diverse engineering components. Overall, students will be equipped to contribute effectively to product development, process planning, and production engineering roles in the manufacturing sector.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand fundamentals of sand casting and special casting processes, their steps, applications, defects, and inspection. (Cognitive Knowledge Level: Understand)
CO 2	Understand fundamental concepts of welding and related joining processes, their classifications, techniques, equipment, metallurgy and defects. (Cognitive Knowledge Level: Understand)
CO 3	Apply fundamental concepts of forging and rolling to analyze process operations, estimate force and power requirements, identify defects, and select appropriate equipment for various metal forming applications. (Cognitive Knowledge Level: Apply)
CO 4	Apply fundamental principles of sheet metal operations to analyze forming processes, calculate forces and allowances, evaluate tool dimensions, and select suitable operations for various sheet metal applications. (Cognitive Knowledge Level: Apply)
CO 5	Understand the principles, types, defects, and applications of extrusion, drawing, and additive manufacturing processes. (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	1	1			1	1		1
CO 2	3	2	1					1	1		1
CO 3	3	3	2	2	2			1	1	1	1
CO 4	3	3	2	1	1			1	1	1	1
CO 5	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	40	40	40
Understand	60	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Casting Processes (9 hours)

Introduction to manufacturing and classification of manufacturing processes.

Casting basics: Overview, significance and classification of casting processes. Sand casting: Pattern types, allowances, sand properties, sand casting steps, core, types of cores, core making, gating system design. Solidification of metals, numerical problems based on Chvorinov's rule. Special casting processes: Shell moulding, investment casting, die casting, centrifugal casting, vacuum mold casting. Casting defects: Causes and remedies. inspection and testing of castings.

MODULE 2: Welding and Joining Processes (9 hours)

Introduction to welding: Classification of metal joining processes, welding classification, welding metallurgy, types of weld joints. Gas welding, techniques, equipment's, types of flame and its applications. Arc welding, equipment's, metal arc welding, MIG, TIG, submerged arc welding. Resistance welding: spot, seam, and projection welding. Solid-state welding: friction, ultrasonic welding. Welding defects- types. Soldering, brazing, and adhesive bonding.

MODULE 3: Module 3: Metal Forming Processes –Forging and Rolling (9 hours)

Forging: significance, classification - open die forging, closed die forging, forging operations, forging equipment (hammer, press). Forging force, numerical problems on forging force. Forging operations - Roll forging, skew rolling, heading. Forging defects and inspection.

Rolling: principles of metal rolling, hot rolling and cold rolling, types of mills. Flat-rolling process: Mechanics, neutral point, pressure distribution, rolling force and power, numerical problems on roll force and power. Rolling defects. Rolling operations: shape rolling, roll forging, ring rolling, thread and gear rolling, rotary tube piercing, tube rolling – applications.

MODULE 4: Sheet Metal Operations (10 hours)

Sheet metal operations: Shearing operations: blanking, punching, piercing, trimming, shaving, nibbing, notching. Clearance between punch and die, numerical problems on dimensions of punch and die, punch force. Tension operations: Stretch forming. Compression operations: Coining, sizing, ironing, hobbing. Tension and Compression operations: Sheet metal drawing, spinning, bending, forming, embossing. Bending Operation: Theory of bending, bending allowance, minimum bend radius, bendability, spring back, tube bending, bending force. Sheet metal drawing process: Drawing tool, drawing force, deep drawing, numerical problems on drawing force. Spinning operation: Conventional, Shear and Tube spinning.

MODULE 5: Extrusion, Drawing and Additive Manufacturing (8 hours)

Extrusion: Types (direct, indirect, impact), extrusion defects. Wire, rod, and tube drawing.

Introduction to Additive Manufacturing (AM) - Principles of AM and data processing. AM techniques, benefits and challenges. Applications for AM: Rapid Prototyping, Industrial tooling, Aerospace, Automobile, Medical etc.

Text Books

1. Serope Kalpakjian & Steven R. Schmid, *Manufacturing Processes for Engineering Materials*, Pearson, 6th Edition.
2. P. N. Rao, *Manufacturing Technology – Foundry, Forming and Welding (Vol. I)*, Tata McGraw-Hill, 3rd Edition.
3. Amitabha Ghosh & Asok Kumar Mallik, *Manufacturing Science*, East-West Press, 2nd Edition.

Reference Books

1. Mikell P. Groover, *Fundamentals of Modern Manufacturing: Materials, Processes, and Systems*, Wiley-India (Wiley), SI Edition.
2. J. T. Black & Ronald A. Kohser, *DeGarmo's Materials and Processes in Manufacturing*, Wiley, 12th Edition.
3. Peter Beeley, *Foundry Technology*, Butterworth-Heinemann, 3rd Edition, 2013.
4. P. N. Rao, *Manufacturing Technology – Machine Tools & Machining (Vol. II)*, Tata McGraw-Hill, 3rd Edition.
5. Kaushik Kumar, Hridayjit Kalita, Divya Zindani & J. Paulo Davim, *Materials and Manufacturing Processes*, Springer India, 1st Edition.
6. C. P. Paul & A. N. Jinoop, *Additive Manufacturing*, McGraw-Hill Education India, 1st Edition.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1: Casting Processes	**9**
1.1	Introduction to manufacturing and classification of manufacturing processes. Casting basics: Overview, significance and classification of casting processes.	1
1.2	Sand casting: Pattern types, allowances, sand properties, sand casting steps, core, types of cores, core making, gating system design.	3
1.3	Solidification of metals, numerical problems based on Chvorinov's rule.	1
1.4	Special casting processes: Shell moulding, investment casting, die casting, centrifugal casting, vacuum mold casting.	3
1.5	Casting defects: Causes and remedies. inspection and testing of castings.	1
	Module 2: Welding and Joining Processes	**9**
2.1	Introduction to welding: Classification of metal joining processes, welding classification, welding metallurgy, types of weld joints.	2

2.2	Gas welding, techniques, equipment's, types of flame and its applications.	1
2.3	Arc welding, equipment's, metal arc welding, MIG, TIG, submerged arc welding.	2
2.4	Resistance welding: spot, seam, and projection welding.	1
2.5	Solid-state welding: friction, ultrasonic welding.	1
2.6	Welding defects- types.	1
2.7	Soldering, brazing, and adhesive bonding.	1
	Module 3: Metal Forming Processes –Forging and Rolling	**9**
3.1	Forging: significance, classification - open die forging, closed die forging, forging operations, forging equipment (hammer, press).	1
3.2	Forging force, numerical problems on forging force.	1
3.3	Forging operations - Roll forging, skew rolling, heading.	1
3.4	Forging defects and inspection.	1
3.5	Rolling: principles of metal rolling, hot rolling and cold rolling, types of mills.	1
3.6	Flat-rolling process: Mechanics, neutral point, pressure distribution, rolling force and power, numerical problems on roll force and power.	2
3.7	Rolling defects.	1
3.8	Rolling operations: shape rolling, roll forging, ring rolling, thread and gear rolling, rotary tube piercing, tube rolling – applications.	1
	Module 4: Sheet Metal Operations	**10**
4.1	Sheet metal operations: Shearing operations - blanking, punching, piercing, trimming, shaving, nibbing, notching.	1
4.2	Clearance between punch and die, numerical problems on dimensions of punch and die, punch force.	2
4.3	Tension operations - Stretch forming. Compression operations – Coining, sizing, ironing, hobbing.	1
4.4	Tension and Compression operations: Sheet metal drawing, spinning, bending, forming, embossing.	1
4.5	Bending Operation: Theory of bending, bending allowance, minimum bend radius, bendability, spring back, tube bending, bending force.	2
4.6	Sheet metal drawing process: Drawing tool, drawing force, deep drawing, numerical problems on drawing force.	2
4.7	Spinning operation: Conventional, Shear and Tube spinning.	1
	Module 5: Extrusion, Drawing and Additive Manufacturing	**8**
5.1	Extrusion: Types (direct, indirect, impact), extrusion defects.	2
5.2	Wire, rod, and tube drawing.	1
5.3	Introduction to Additive Manufacturing (AM) - Principles of AM and data processing.	2
5.4	AM techniques, benefits and challenges.	2
5.5	Applications for AM: Rapid Prototyping, Industrial tooling, Aerospace, Automobile, Medical etc.	1
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain five desirable properties of moulding sand.
2. Describe various types of patterns with sketches.
3. With a neat and labelled sketch, describe the Investment casting process. List advantages and application of the process.

Course Outcome 2 (CO2):

1. Describe Heat Affected Zone (HAZ) in fusion welding. Explain various regions of heat affected zone with a sketch.
2. Explain different types of welding flames in oxy acetylene gas welding with neat sketches.
3. Explain the arc welding equipment with a schematic diagram showing the components.

Course Outcome 3 (CO3):

1. With the help of neat sketches, explain the differences between open die forging and closed die forging.
2. Explain with suitable sketch any five forging operations.
3. Sketch and explain cluster and planetary rolling mill arrangements in rolling process.

Course Outcome 4 (CO4):

1. Explain spring back effect in bending. Suggest two methods to combat spring back.
2. Describe the following processes with a neat sketch (a) Stretch forming (b) Deep drawing.
3. With a neat sketch explain the following processes (a) Shear Spinning (b) Tube Spinning.

Course Outcome 5 (CO5)

1. Differentiate between Extrusion and drawing process.
2. What is additive manufacturing?
3. Write a note on the benefits and applications of additive manufacturing.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIFTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: **B24ME3T03**

Course Name: **MANUFACTURING TECHNOLOGY**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1	Why draft allowances are important for patterns.
2	Describe the desirable properties of moulding sand.
3	Explain resistance seam welding with a neat sketch.
4	Differentiate between soldering and brazing.
5	Justify why forged parts withstand high loads compared to cast parts.
6	Explain a suitable rolling process for making threaded fasteners.
7	List out any four factors on which the bending force on a sheet metal depends upon.
8	Distinguish between blanking and punching operations.
9	Differentiate between extrusion and drawing process.
10	Identify a real-world part that is easier to manufacture by additive manufacturing than by casting or machining. Justify your choice.

PART B

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

Module 1

11 a. A cylindrical-shaped component is to be cast out of aluminium. The radius of the cylinder is 250 mm, and its height is 20 mm. If the mould constant C = 2.0 sec/mm^2 in Chvorinov's Rule, how long will it take the casting to solidify? (7 marks)

b. With a neat sketch, explain the role of various components of gating system in casting. (7 marks)

OR

12 Explain different types of casting defects in detail with effects of each defect on quality of the casting. (14 marks)

Module 2

13 a. Describe Heat Affected Zone (HAZ) in fusion welding. Explain various regions of heat affected zone with a sketch. (7 marks)

b. Explain submerged arc welding with a neat, labelled diagram. List out two advantages and disadvantages of submerged arc welding. (7 marks)

OR

14 a. With a neat sketch, explain the characteristics of different types of flames used in gas welding. (7 marks)

b. Describe the principle and application of resistance welding with neat sketches. (7 marks)

Module 3

15 a. Sketch and explain cluster and planetary rolling mill arrangements in rolling process. (7 marks)

b. Describe any four defects that may arise during forging process. (7 marks)

OR

16 a. An annealed Copper strip 228mm wide and 25mm thick is rolled to a thickness 20mm in one pass. The roll radius is 300mm and the rolls rotate at 100rpm. Calculate the roll force and the power required in this operation. Average flow stress of copper is 180MPa. (7 marks)

b. With neat sketches explain open die and closed die forging operations. (7 marks)

Module 4

17 a. Determine the die and punch sizes for blanking a circular disc of 20mm diameter from a C20 steel sheet whose thickness is 1.5mm. (7 marks)

b. Describe with sketches (a). deep drawing (b). Stretch forming. (7 marks)

OR

18 a. With a neat sketch and explain the following processes

(a) Shear Spinning (b) Tube Spinning. (7 marks)

b. Explain spring back effect in bending. Suggest two methods to combat spring back. (7 marks)

Module 5

19 a. Differentiate between direct extrusion and indirect extrusion with simple sketches. (7 marks)

b. Explain applications of additive manufacturing. (7 marks)

OR

20 a. Explain the process and set up used for manufacturing thin metallic wires with a schematic diagram. (7 marks)

b. Describe the benefits and applications of additive manufacturing. (7 marks)

B24ME3T04	ROBOTICS AND AUTOMATION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course offers a comprehensive introduction to robotics and industrial automation, focusing on the principles governing robot architecture, kinematics, differential motion, dynamics, trajectory generation, and fundamental control concepts. It emphasizes the modelling and analysis of robotic systems and their deployment in practical industrial and service applications. In addition, the course introduces essential automation elements, including sensors, actuators, programmable logic controllers (PLCs), and industrial communication systems, supported by illustrative case studies on autonomous mobile robots (AMRs), automated storage and retrieval systems (AS/RS), and automated material handling solutions. Collectively, these topics establish a strong foundation for advanced learning and hands-on applications in robotics and automation.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the basics of robotics and its applications. (Cognitive Knowledge Level: Understand)
CO 2	Apply spatial transformation principles and kinematic modelling techniques to analyse robotic manipulators. (Cognitive Knowledge Level: Apply)
CO 3	Apply differential kinematics and Jacobian concepts to analyse robot velocities and forces. (Cognitive Knowledge Level: Apply)
CO 4	Apply fundamental principles of robot dynamics, trajectory generation, and basic control to describe robot motion behaviour. (Cognitive Knowledge Level: Apply)
CO 5	Understand the basic automation concepts through PLCs, sensors, and industrial case studies. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	20	10	15
Understand	40	30	35
Apply	40	60	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts: Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each, and the student should answer all the questions. Part B contains 2 questions from each module, of which the student should answer any one. Each question can have a maximum of 2 subdivisions and carry 14 marks.

SYLLABUS

MODULE 1: Introduction to Robotics (8 hours)

Definition and classifications of robots. Basic components—links, joints, actuators, sensors, end-effectors, and controllers. Robot configurations, degrees of freedom, concept of workspace, reachability, and manipulability. Overview of robot applications in industrial and service domains.

MODULE 2: Manipulator Kinematics (10 hours)

Spatial description of the position and orientation of rigid bodies-rotation and translation. Transformation of coordinates using homogeneous transformation matrices, successive transformation, and inverse transformations. Forward kinematics- full parameter and Denavit–Hartenberg (DH) representation, Basics of inverse kinematics for serial robots.

MODULE 3: Differential Kinematics and Statics (9 hours)

Forward differential kinematics and velocity propagation. Manipulator Jacobian- definition and computation, inverse differential kinematics. Static force analysis- Jacobian in force domain, introduction to singularities, and dexterity.

MODULE 4: Robot Dynamics, Trajectory Planning and Control (10 hours)

Equations of motion of robotic manipulators, forward and inverse dynamics. Dynamic formulation using Euler–Lagrange equation and Newton–Euler method, dynamic modelling of a simple robotic arm. Trajectory planning- trajectory and path, joint-space and task-space trajectory generation. Introduction to robot motion control-classification of control schemes.

MODULE 5: Industrial Automation (8 hours)

Introduction to industrial automation—types of automation. Industrial automation components- sensors, actuators, controllers, safety devices, and communication systems. Introduction of Programmable Logic Controllers (PLC), vision systems and IoT technologies in automation. Case studies in factory automation- warehouse automation using AMRs, AS/RS systems, robotic arms for material handling, and AI-enabled inventory management.

Text Books

1. Craig, J. J., *Introduction to Robotics: Mechanics and Control*, Pearson Education.
2. Ghosal, A., *Robotics: Fundamental Concepts and Analysis*, Oxford University Press.
3. Saha, S. K., *Introduction to Robotics*, McGraw-Hill Education.

Reference Books

1. Spong, M. W., Hutchinson, S., & Vidyasagar, M., *Robot Modeling and Control*, John Wiley & Sons.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**8**
1.1	Definition and classifications of robots.	1
1.2	Basic components—links, joints, actuators, sensors, end-effectors, and controllers.	3
1.3	Robot configurations, degrees of freedom, concept of workspace, reachability, and manipulability.	2
1.4	Overview of robot applications in industrial and service domains.	2
	Module 2	**10**
2.1	Spatial description of the position and orientation of rigid bodies- rotation and translation.	2
2.2	Transformation of coordinates using homogeneous transformation matrices, successive transformation, and inverse transformations.	3
2.3	Forward kinematics- full parameter and Denavit–Hartenberg (DH) representation.	3
2.4	Basics of inverse kinematics for serial robots.	2
	Module 3	**9**
3.1	Forward differential kinematics and velocity propagation.	3
3.2	Manipulator Jacobian- definition and computation, inverse differential kinematics.	2
3.3	Static force analysis- Jacobian in force domain.	3
3.4	Introduction to singularities and dexterity.	1
	Module 4	**10**
4.1	Equations of motion of robotic manipulators, forward and inverse dynamics.	2
4.2	Dynamic formulation using Euler–Lagrange equation and Newton–Euler method, dynamic modelling of a simple robotic arm.	3
4.3	Trajectory planning- trajectory and path, joint-space and task-space trajectory generation.	3
4.4	Introduction to robot motion control-classification of control schemes.	2
	Module 5	**8**
5.1	Introduction to industrial automation—types of automation.	1
5.2	Industrial automation components- sensors, actuators, controllers, safety devices, and communication systems.	2
5.3	Introduction of Programmable Logic Controllers (PLC), vision systems and IoT technologies in automation.	3
5.4	Case studies in factory automation- warehouse automation using AMRs, AS/RS systems, robotic arms for material handling, and AI-enabled inventory management.	2
	Total	**45 hours**

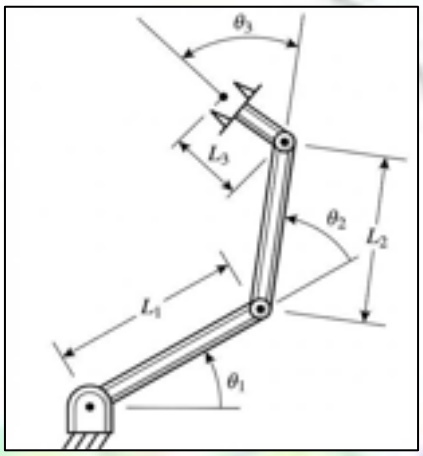
CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

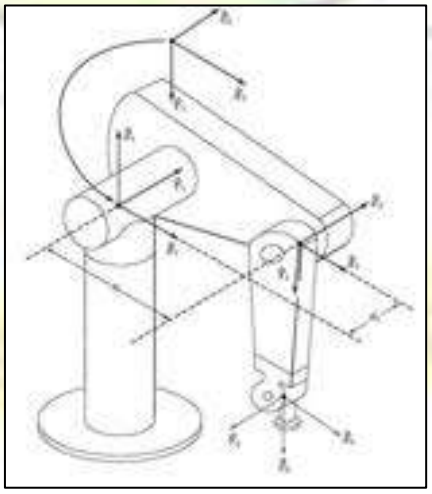
1. Explain the basic components of a robot with suitable examples for each component.
2. Differentiate between various robot configurations and discuss how they influence workspace and reachability.
3. Describe any three major applications of robots in industrial domains and explain why robots are suitable for those tasks.

Course Outcome 2 (CO2):

1. Compute the forward kinematics of the 3-link planar arm shown in the figure



2. Develop the DH parameter table for the PUMA 560 robot arm shown in the figure using the DH algorithm.



3. Compute the individual homogeneous transformation matrices for each link of a 3-link planar manipulator, and determine the end-effector pose for a given set of joint angles.

Course Outcome 3 (CO3):

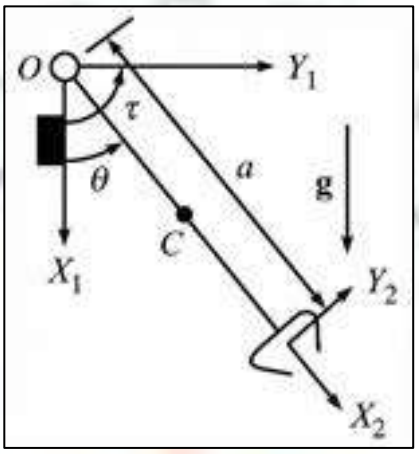
1. Calculate the Jacobian of a two-link planar arm when $\theta_1 = 45^0$ and $\theta_1 = 20^0$.
2. For a 2-link planar robot, derive the Jacobian matrix and compute the end-effector linear

velocity for a given set of joint angles and joint velocities.

3. Using the force relationship $\boldsymbol{\tau} = \mathbf{J}^T \boldsymbol{F}$, determine the joint torques required to balance a known end-effector force $[F_x, F_y]^T$ applied in the X–Y plane.

Course Outcome 4 (CO4):

1. For the one-link arm shown in the figure, assume that the link is massless, whereas the end-effector has mass m. Derive its equation of motion.



2. A single-link robot with a rotary joint is motionless at $\theta = 15°$. It is desired to move the joint in a smooth manner to $\theta_f = 75°$ in 3 seconds. Find the coefficients of a cubic that accomplishes this motion and brings the manipulator to rest at the goal.
3. Select an appropriate control scheme for a specified motion-tracking problem and justify the choice.

Course Outcome 5 (CO5):

1. Describe the basic working principle of a Programmable Logic Controller (PLC) and explain how it is used to control an automated process.
2. Explain any one industrial automation case study and discuss how automation improves efficiency in that application.
3. Describe how IoT technologies are used in modern factories to monitor and control automated systems.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIFTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: **B24ME3T04**

Course Name: **ROBOTICS AND AUTOMATION**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the concept of degrees of freedom (DOF) and its significance in determining robot capability.
2. Describe the major components of a robot.
3. Explain how homogeneous transformation matrices are used to represent rotation and translation between coordinate frames.
4. Explain the difference between forward kinematics and inverse kinematics in robotic manipulators.
5. Define the manipulator Jacobian.
6. What is a kinematic singularity? Explain its effect on robot motion and control.
7. Explain the difference between path and trajectory in robot motion.
8. Explain the difference between the joint-space trajectory and the task-space trajectory.
9. Explain the role of PLCs in industrial automation.
10. Explain the role of sensors in industrial automation with one example.

PART B

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

Module 1

11. a. Describe in detail the different robot configurations. Explain how configuration affects the robot's motion and workspace. (7 marks)

    b. Explain the major classifications of robots with suitable examples. Discuss how these classifications help in selecting robots for different industrial tasks. (7 marks)

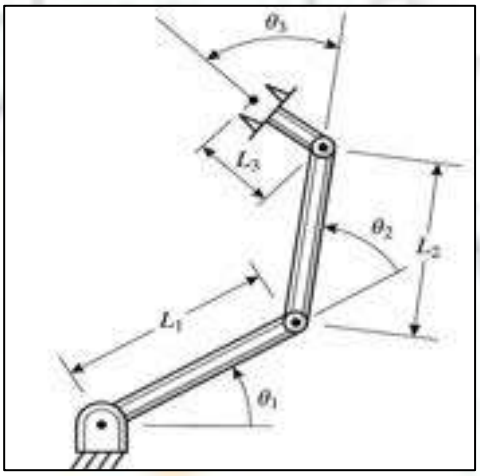
OR

12. a. Explain the concepts of workspace, reachability, and manipulability. Discuss how these parameters influence the capability of a robotic manipulator. (7 marks)

    b. Discuss the various applications of robots in industrial and service sectors. (7 marks)

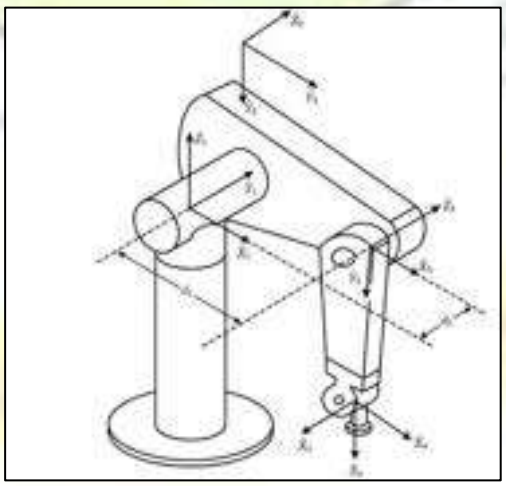
Module 2

13. Compute the forward kinematics of the 3-link planar arm shown in the figure. (14 marks)



OR

14. Develop the DH parameter table for the PUMA 560 robot arm, as shown in the figure, using the DH algorithm. (14 marks)



Module 3

15. a. Calculate the Jacobian of a two-link planar arm when $\theta_1 = 45^0$ and $\theta_1 = 20^0$. (7 marks)

    b. For a 2-link planar robot, derive the Jacobian matrix and compute the end-effector linear velocity for a given set of joint angles and joint velocities. (7 marks)

OR

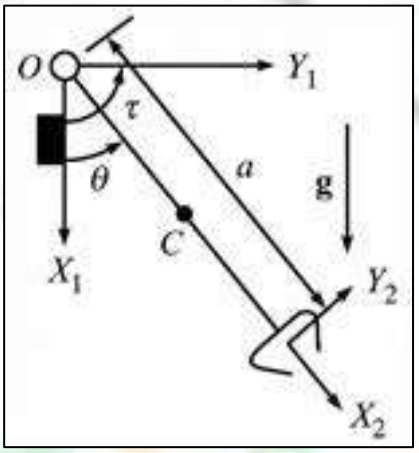
16. a. Using the force relationship $\boldsymbol{\tau} = \mathbf{J}^T \boldsymbol{F}$, determine the joint torques required to balance a known end-effector force $[\boldsymbol{F_x}, \boldsymbol{F_y}]^T$ applied in the X–Y plane. (7 marks)

b. Explain inverse differential kinematics and describe how the Jacobian pseudo-inverse is used to compute joint velocities from a desired Cartesian velocity.

(7 marks)

Module 4

17. For the one-link arm shown in the figure, assume that the link is massless, whereas the end-effector has mass *m*. Derive its equation of motion. (14 marks)



OR

18. A single-link robot with a rotary joint is motionless at $\theta = 15°$. It is desired to move the joint in a smooth manner to $\theta_f = 75°$ in 3 seconds. Find the coefficients of a cubic that accomplishes this motion and brings the manipulator to rest at the goal. (14 marks)

Module 5

19. Describe the basic working principle of a Programmable Logic Controller and explain with an example how it is used to control an automated process. (14 marks)

OR

20. Explain any one industrial automation case study and discuss how automation improves efficiency in that application. (14 marks)

B24ME3T05	INDUSTRIAL AND SYSTEMS ENGINEERING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces the fundamental principles and practices of Industrial Engineering aimed at improving productivity, efficiency, and quality in manufacturing and service systems. Students learn the basics of product design, plant layout, material handling, methods engineering, and production planning and control. The syllabus also covers modern approaches such as Lean and Agile manufacturing, ERP systems, and essential quality management tools. By integrating foundational concepts with contemporary industrial practices, the course prepares students to analyze processes, optimize resources, and contribute effectively to organizational improvement.

Prerequisites

Nil

Course Outcomes

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

CO 1	Outline the scope of Industrial Engineering, identify major production types, and describe fundamental product design considerations involving quality, cost, and human factors. (Cognitive Knowledge Level: Understand)
CO 2	Explain plant layout types, material handling systems, and basic methods engineering tools. (Cognitive Knowledge Level: Understand)
CO 3	Apply production planning concepts, use inventory models and maintenance strategies, and implement appropriate methods for effective control of production activities. (Cognitive Knowledge Level: Apply)
CO 4	Explain the core concepts of Lean and Agile manufacturing and describe the purpose of ERP systems and their role in integrating organizational processes. (Cognitive Knowledge Level: Understand)
CO 5	Make use of quality management tools and statistical quality control techniques to assess process performance and support continuous improvement. (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	1							1	1
CO 2	3	2	2		1					1	1
CO 3	3	3	2	1	1					2	2
CO 4	2	1	1	1	2					1	1
CO 5	3	2	2	1	2					1	1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	10	10
Understand	60	50	50
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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Fundamentals of Industrial Engineering and Product Design (7 hours)

Introduction: Scope and functions of Industrial Engineering - Types of production (batch, flow and unit), Roles of line supervisors and production managers.

Product Development and Design: Objectives - Quality and cost considerations - Human factors in design - Detailed design & prototyping - Functionality & manufacturability - Standardization, simplification- Value engineering.

MODULE 2: Plant Layout, Material Handling, and Work Study (7 hours)

Plant layout and Material handling: Types of plant layout - Principles of material handling - Material handling equipment - Types, selection and application.

Methods engineering; Analysis of work methods using different types of process chart and flow diagrams, Micro motion study, Principles of motion economy, Determination of allowances and standard time.

MODULE 3: Production Planning, Inventory, and Maintenance Management (7hours)

Production planning and control: Importance of planning, Functions of production control, need for a new product, product life cycle, Materials requirement planning, Supply chain and management.

Inventory Management: EOQ models, P system, Q system, reorder level, Types of Maintenance; Break down- preventive- predictive maintenance,

MODULE 4: Lean, Agile Manufacturing and Enterprise Resource Planning (8 hours)

Lean Manufacturing (LM): Basic elements - Tools - Concept of wastes - stages of 5S and waste elimination - Need for LM, Agile manufacturing: Definition, conceptual framework, characteristics and generic features - Approaches to enhance agility in manufacturing.

Enterprise resource planning (ERP): Concept of Enterprise, ERP Overview - Integrated information system - ERP implementation - Benefits, challenges, success and failure factors.

MODULE 5: Quality Management and Statistical Quality Control (7 hours)

Quality Management; Quality, quality planning, quality control, quality assurance, quality management - TQM, ISO, Six Sigma and Quality circle (Brief description only).

Statistical Quality Control; Process capability - Causes of variation in quality- Control charts for $\bar{x}$ and R - Acceptance sampling, Reliability.

Text Books

1. M. T. Telsang, *Industrial Engineering & Production Management*, S Chand & Co.
2. Paneerselvam. R, *Production and Operations Management,* PHI Learning.
3. B. Mahadevan, *Operations Management: Theory and Practice,* Pearson Education.

Reference Books

1. Philips E. Hicks, *Industrial Engineering and Management — A new perspective*, McGraw Hill.
2. Douglas C. Montgomery, *Introduction to Statistical Quality Control,* Wiley Eastern.
3. Amitava Mitra, *Fundamentals of Quality Control and Improvement*, Wiley Eastern.
4. Introduction to work study-ILO, Oxford and IBH Publishing.
5. Krajewski, L. J., Malhotra, M. K. S. K. Srivastava and L. P. Ritzman, *Operations Management: Processes and Supply Chains, An Introduction*, Pearson Education.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Functions of Industrial Engineering and types of production systems	2
1.2	Roles of line supervisors and production managers	1
1.3	Product development and design objectives, Quality and cost considerations, prototyping.	2
1.4	Functionality and manufacturability, Standardization and simplification, Concurrent engineering.	2
	Module 2	**7**
2.1	Types of plant layout and Principles of material handling	1
2.2	Material handling equipment's, Different types of material handling and selection	2
2.3	Analysis of work methods using different types of process chart and flow diagrams**,**	2
2.4	Principles of motion economy and determination of allowances and standard time.	2
	Module 3	**7**
3.1	Production planning and control, Functions of production control, and product life cycle.	2
3.2	Material requirement planning, Supply chain and management	2
3.3	Inventory Management; P system, Q system and EOQ	2
3.4	Types of Maintenance; Break down- preventive- predictive maintenance.	1
	Module 4	**8**
4.1	Basic elements and tools of lean manufacturing, Concept of wastes and stages of 5S and waste elimination	2
4.2	Conceptual frame work and generic features of Agile manufacturing, Approaches to enhance agility in manufacturing.	2
4.3	Concept of Enterprise, Overview of enterprise resource planning and Integrated information system	2

4.4	ERP implementation; Benefits, challenges, success and failure factors	2
	Module 5	**7**
5.1	Quality; Quality planning, quality control, quality assurance, quality management	2
5.2	TQM, ISO, Six Sigma and Quality circle	2
5.3	Process capability and causes of variation in quality, Control charts for $\bar{x}$ and R, Acceptance sampling	2
5.4	Reliability.	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Define Industrial Engineering and list its main functions.
2. List the roles of production manager in an organization
3. Explain the objectives of product development and design.

Course Outcome 2 (CO2):

1. Name the types of plant layout and mention one advantage of each.
2. Summarize the different types of material handling equipment's.
3. Illustrate the concept of motion economy.

Course Outcome 3 (CO3):

1. What is the role of production planning in a manufacturing system?
2. Explain EOQ and reorder level in inventory management.
3. Discuss various types of maintenance (breakdown, preventive, predictive) and their importance in production systems.

Course Outcome 4 (CO4):

1. Understand the elements and tools of lean manufacturing.
2. List out the approaches to enhance agility in manufacturing.
3. Discuss the concept of ERP, its implementation process, and benefits in an organization.

Course Outcome 5 (CO5)

1. Demonstrate the need of quality control.
2. Detail the concept of Total Quality Management (TQM).
3. Define process capability in statistical quality control.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIFTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: **B24ME3T05**

Course Name: **INDUSTRIAL AND SYSTEMS ENGINEERING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1	Outline the key functions of Industrial Engineering?
2	Elaborate the importance of 'standardization' and 'simplification' in product development and design?
3	Name the types of plant layout and mention one advantage of each.?
4	Discuss the concept of motion economy?
5	What is the role of production planning in a manufacturing system?
6	Differentiate between P-system and Q-system?
7	Name the approaches to enhance the agility in manufacturing
8	List any four types of wastes identified in Lean Manufacturing.
9	Elaborate the concept quality control?
10	Define process capability in statistical quality control.

PART B

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

Module 1

11	a.	Explain the key considerations in product design with respect to quality, cost, and human factors.	(7 marks)
	b.	Describe the roles and responsibilities of line supervisors and production managers in a manufacturing organization?	(7 marks)

OR

12		Elaborate the concepts of standardization, simplification, and value engineering, highlighting their importance in improving product efficiency?	(14 Marks)

Module 2

13 a. Explain the advantages, disadvantages, and typical applications of product and process layout. (7 marks)

b. Explain the principles of material handling and discuss the criteria for selecting material handling equipment. (7 marks)

OR

14 Define work study. With a neat diagram, explain the steps involved in method study. Illustrate any two-method study tools. (14 marks)

Module 3

15 a. Discuss the steps involved in routing, loading, and scheduling. (7 marks)

b. Detail, how an effective supply chain management can improve the performance of a manufacturing organisation. (7 marks)

OR

16 A manufacturer has to supply 8,000 units of product annually. The unit cost is Rs. 2 and it costs Rs.26 to place an order. The inventory carrying cost is estimated at 9% of average inventory investment. Determine

1. EOQ

2.Optimum number of orders to be placed per annum.

3.Minimum total cost of inventory (14 marks)

Module 4

17 Explain the fundamental elements of Lean Manufacturing and discuss how each element contributes to improving productivity and eliminating waste in a manufacturing system? (14 marks)

OR

18 a. "Enterprises are socio-economic systems." Analyse this statement and discuss how enterprises balance economic goals with social responsibilities? (7 marks)

b. Discuss the stages involved in ERP implementation. Suggest strategies for successful implementation? (7 marks)

Module 5

19 a. Explain the various dimensions of TQM and Six Sigma concept. (7 marks)

b. Give an account of the new major features of ISO9000 quality system. (7 marks)

OR

20 a. Illustrate the components of process capability and detail the advantages of using statistical methods for quality control? (7marks)

b. Given an R-chart with:
UCL=4.2, CL=2.5, LCL=0.8
The latest subgroup ranges are: 2.4, 2.0, 2.9, 3.2, 4.8

Tasks:

. a) Determine if the process variability is in control.
b) Explain what it means when R exceeds UCL.
c) List two possible assignable causes of high variability. (7 marks)

B24ME3P11	OPERATIONS MANAGEMENT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course is designed to provide a comprehensive understanding of the process and operations carried out in an industry, which are essential to solving problems in the related fields. This course will provide a basic foundation in applying operations concepts to real-world scenarios, with a particular focus on demand forecasting, inventory models, and aggregate planning. The course also introduces key job shop production activities to enhance operational efficiency.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the role and evolution of operations management and apply its strategic impact on organizational productivity. (Cognitive Knowledge Level: Understand)
CO 2	Compute the demand forecast and forecast accuracy. (Cognitive Knowledge Level: Understand)
CO 3	Apply different inventory models and effectively manage inventory to optimize stock levels and minimize risks. (Cognitive Knowledge Level: Apply)
CO 4	Proficient in developing aggregate plans and applying advanced planning systems for efficient operations. (Cognitive Knowledge Level: Apply)
CO 5	Effectively plan and schedule job shop production activities and apply modern production system principles to enhance operational efficiency. (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	2	2	1	-	1	2	-	2
CO 2	3	2	2	2	2	-	-	2	2	2	2
CO 3	3	3	3	2	2	-	-	2	2	2	2
CO 4	3	3	3	2	2	-	-	2	2	2	2
CO 5	3	3	3	2	2	-	-	2	2	2	2

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	10	10
Understand	60	30	30
Apply		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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Operations Strategy and Facility Planning (8 Hours)

Operations management – role and evolution – manufacturing system types (job shop, batch, mass) – operations strategy – productivity – facility location factors – factor rating and center of gravity methods – facility layout types and comparison – systematic layout planning (SLP) – introduction to layout planning software.

Module 2: Demand Forecasting and Forecast Accuracy (7 Hours)

Need for forecasting – qualitative and quantitative forecasting – time series and causal models – moving average and exponential smoothing – trend, cycle, and seasonality components – forecast error analysis – comparison of methods based on errors – application in production and capacity planning.

Module 3: Aggregate Planning and Production Resource Planning (7 Hours)

Aggregate planning – decision rules – pure and mixed strategies – mathematical models – transportation method – master production schedule – bill of materials (BOM) – material requirement planning (MRP) – introduction to MRP-II and ERP – basic implementation considerations.

Module 4: Inventory Management and Selective Control (7 Hours)

Inventory objectives and types – EOQ and EBQ models – models for uniform and variable demand with and without shortages – quantity discount models – safety stock – selective inventory control techniques – ABC, XYZ, and VED analyses – role of inventory decisions in cost optimization.

Module 5: Production Scheduling and Shop Floor Control (7 Hours)

Production scheduling objectives and constraints – single machine scheduling – shop loading – SPT and EDD rules – makespan minimization – flow shop scheduling – Johnson's rule (2–3 machine extension) – Palmer's heuristic – application to job shop and flow shop environments.

Text Books

1. Lee J. Krajewski, Manoj Malhotra, *Operations Management: Processes and Supply Chains*, Pearson Education.
2. William J. Stevenson, *Operations Management*, McGraw-Hill Education.
3. Chary S. N, *Production and Operations Management,* McGraw-Hill.
4. Paneerselvam. R, *Production and Operations Management,* PHI Learning.

Reference Books

1. Jay Heizer, Barry Render, Chuck Munson, *Operations Management: Sustainability and Supply Chain Management,* Pearson.
2. Cecil B. Bozarth, Robert B. Handfield, *Introduction to Operations and Supply Chain Management*, Pearson.
3. B. Mahadevan, *Operations Management:Theory and Practice: An Introduction*, Pearson.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
Module 1: Operations Strategy and Facility Planning		**8**
1.1	Operations management – role and evolution	2
1.2	historical evolution and perspectives, manufacturing system types (job shop, batch, mass) – operations strategy – productivity	2
1.3	Facility Location and Layout: Factors influencing location planning, factor rating and center of gravity methods of location selection.	2
1.4	Types of facility layouts, comparison of layouts. Systematic Layout Planning (SLP), software packages for SLP.	2
Module 2: Demand Forecasting and Forecast Accuracy		**7**
2.1	Needs and use of forecasting methods	1
2.2	Causal and time series models, moving average method	2
2.3	Exponential smoothing methods. Trend, cycle, and seasonality components	2
2.4	Types of forecasting errors and analysis of forecast error	1
2.5	Comparison of forecasting methods based on errors	1
Module 3: Aggregate Planning and Production Resource Planning		**7**
3.1	Aggregate Planning and the value of decision rules	1
3.2	Pure and Mixed strategies, Mathematical Models for Aggregate planning	2
3.3	Transportation Method	1
3.4	Master production schedule (MPS), Bill of Material (BOM), MRP and Implementation issues	2
3.5	MRP – II, Introduction to ERP	1
Module 4: Inventory Management and Selective Control		**7**
4.1	Objectives and Types of Inventories	1
4.2	EOQ and EBQ models for uniform and variable demand with and without shortages	2
4.3	Quantity discount models, safety stock	2
4.4	Selective Inventory Control: ABC Analysis, XYZ Analysis, VED Analysis	2
Module 5: Production Scheduling and Shop Floor Control		**7**
5.1	Production Scheduling, objectives-process characteristics and constrains	1
5.2	Single machine scheduling, shop loading, minimization of makespan	2
5.3	Flow shop scheduling; extension of Johnson's rule- 3 machine problem	2
5.4	Palmer's heuristic.	1
5.5	Application to job shop and flow shop environments	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Demonstrate the concept of operations management.
2. List the strategies to improve productivity in an organization
3. Determine the location of the facility.

Course Outcome 2 (CO2):

1. Demonstrate the need and uses of demand forecasting.
2. Compute demand forecast.
3. Comparison of forecasting based on errors.

Course Outcome 3 (CO3):

1. Illustrate the concept of Inventory models
2. Derive an expression for EOQ
3. Comparison of selective inventory control techniques

Course Outcome 4 (CO4):

1. Compare aggregate planning strategies.
2. Compute APP using mathematical models.
3. List out the implementation issues of MRP.

Course Outcome 5 (CO5)

1. Illustrate the concept of production scheduling.
2. Find production schedule using various techniques.
3. Detail the concept of Lean Manufacturing.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIFTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: **B24ME3P11**

Course Name: **OPERATIONS MANAGEMENT**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Elaborate the system concept of production?

2 Identify the critical factors influencing the facility location.

3 Detail about the qualitative methods of forecasting.

4 What is forecasting accuracy?

5 Differentiate between level production strategy and chase demand strategy.

6 Identify the basic inputs for MRP.

7 Identify the different types of inventory cost.

8 What are the different types of replenishment systems in inventory control?

9 Explain the concept of the single machine scheduling problem.

10 Detail about lean manufacturing.

PART B

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

Module 1

11 a. What activities are involved in the operations function? How do operations interact with other functional areas? (7 marks)

b. The data regarding five existing facilities which are to be served by a single new facility is given in the table.

Existing facility (i)	1	2	3	4	5
Coordinates	5,10	20,5	15,20	30,25	25,5
No. of loads/year	100	300	200	300	100

Find the optimal location for a new facility using gravity location concept? (7 marks)

OR

12 A company is attempting to determine the location for a new outlet mall. The region where the outlet mall will be constructed includes four towns, which together have a sizable population base. The grid map coordinates of the four towns and the population of each are as follows:

Town	Coordinates		Population
	X	Y	
A	1000	1250	7000
B	1500	2700	9000
C	2000	700	11500
D	32	25	4300

a. Determine the best location for the outlet mall using the centre-of-gravity method.

b. Plot four towns and the location of the new mall on a grid map. (14 marks)

Module 2

13 a. How does adjusted exponential smoothing differ from exponential smoothing? What determines the choice of the smoothing constant for trend in an adjusted exponential smoothing model? (7 marks)

b. The following table represents the sales data of milk (in litres) sold by a milk booth.

Month	1	2	3	4	5	6	7
Sales	90	106	92	114	108	98	115

Compute the forecast for the 8^{th} month using four month moving average method. (7 marks)

OR

14 a. Detail about the different types of forecasting errors. (4 marks)

b. Using the data provided below, find MAPE, MAD and Tracking Signal, also infer about the values of tracking signal? (10 marks)

Period	**Demand**	**Forecast**
1	120	109
2	114	118
3	130	132
4	124	110
5	97	110

Module 3

15 Explain the different methods of selective inventory control. (14 marks)

OR

16 a. Illustrate about economic order quantity? Derive an expression for EOQ? (7 marks)

b.

The annual demand of an item in a company is 50,000 units. The cost of placing an order is Rs.250. Each item costs Rs.10. Carrying costs are 10% per year per unit of average inventory. Determine

i) Economic order quantity
ii) Cycle time
iii) Total variable cost of managing inventory (7 marks)

Module 4

17 Find the feasible solution for the transportation problem using Vogel's approximation method. The demand and supply at different origins are given in the table.

Origin	D1	D2	D3	Supply
O1	4	14	8	10
O2	6	6	2	16
O3	10	8	14	14
O4	2	12	4	28
Demand	14	18	36	

(14 marks)

OR

18 a. Illustrate the help of a block diagram, the role of APP in the master production schedule. (7 marks)

b. Detail about the role ERP in production scheduling. (7 marks)

Module 5

19 Consider the single machine scheduling problem

Job (j)	Processing Time (t_j) min					
	1	2	3	4	5	6
Machine 1	5	10	8	9	6	12
Machine 2	7	8	13	7	11	10

Using Johnson's algorithm, obtain optimal sequence which will minimize the make span time. (14 marks)

OR

20 Discuss in detail about approach used in Palmer's heuristic? (14 marks)

B24ME3P12	ORGANIZATIONAL BEHAVIOUR & HUMAN RESOURCES MANAGEMENT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Modern engineering organizations require engineers to effectively manage people, teams, and workplace relationships in addition to technical systems. This course introduces fundamental concepts of organizational behaviour and human resource management relevant to engineering and manufacturing environments. It enables students to understand individual and group behaviour, leadership, motivation, HR functions, and industrial relations, supporting ethical, productive, and sustainable engineering practice.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain fundamental concepts of organizational behaviour and individual behaviour in engineering organizations. (Cognitive Knowledge Level: Understand)
CO 2	Outline motivation theories, leadership styles, and communication processes in industrial settings. (Cognitive Knowledge Level: Understand)
CO 3	Explain group behaviour, team dynamics, conflict, and decision-making processes. (Cognitive Knowledge Level: Understand)
CO 4	Summarize core human resource management functions such as planning, recruitment, performance appraisal, and training. (Cognitive Knowledge Level: Understand)
CO 5	Explain industrial relations, labour legislation, ethical practices, and contemporary HR challenges in manufacturing industries. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	2	1	–	–	–	–	–	–	–	–	–
CO 2	2	1	–	–	–	–	–	1	2	2	–
CO 3	1	1	–	–	–	–	–	1	2	2	–
CO 4	2	1	–	–	–	–	–	1	2	2	2
CO 5	1	–	–	–	–	2	1	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	60
Apply			
Analyse			
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Fundamentals of Organizational Behaviour (7 Hours)

Nature and scope of organizational behaviour – importance of OB in engineering organizations – challenges of managing human behaviour in manufacturing environments.

Individual behaviour – personality theories – perception and attribution – attitudes and values – learning theories – emotional intelligence – job satisfaction – work stress and stress management.

Module 2: Motivation, Leadership, and Communication (7 Hours)

Motivation – concept and importance – content theories (Maslow, Herzberg, McClelland) – process theories (expectancy and equity concepts) – motivation techniques in industrial organizations.

Leadership – concept and functions – leadership styles – managerial grid – situational leadership – power and politics.

Communication – communication process – barriers – interpersonal, group, and organizational communication – role of communication in engineering teams.

Module 3: Group Behaviour and Team Dynamics (7 Hours)

Group behaviour – formal and informal groups – stages of group development – team building – characteristics of effective teams – self-managed and cross-functional teams.

Conflict – types and sources – conflict management strategies – negotiation – group decision-making techniques – dynamics of multidisciplinary engineering teams.

Module 4: Human Resources Management Functions (8 Hours)

Human resource management – objectives and scope – role of HRM in manufacturing organizations.

Human resource planning – job analysis and job design – recruitment and selection – induction and socialization.

Performance management – performance appraisal methods – compensation and reward systems – employee engagement – training and development – career planning.

Module 5: Industrial Relations, HR Ethics, and Contemporary Issues (7 Hours)

Industrial relations – concepts and importance – trade unions – collective bargaining – grievance handling and disciplinary procedures – labour welfare.

Labour legislation (overview) – Factories Act – Industrial Disputes Act – social security provisions.

Ethics and corporate social responsibility in HRM – contemporary HR practices – HR analytics – impact of automation, digitalization, and Industry 4.0 on human resources.

Textbooks

1. Aswathappa K., *Organizational Behaviour*, Himalaya Publishing House.

2. Prasad L. M., *Organizational Behaviour*, Sultan Chand & Sons, New Delhi.
3. Rao V. S. P., *Human Resource Management: Text and Cases*, Excel Books, New Delhi.

Reference Books

1. Dwivedi R. S., *Human Relations and Organizational Behaviour*, Macmillan India.
2. Stephen P. Robbins & Timothy A. Judge, *Organizational Behaviour*, Pearson Education.
3. Gary Dessler, *Human Resource Management*, Pearson Education.
4. Fred Luthans, *Organizational Behavior*, McGraw-Hill Education.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
Module 1: Fundamentals of Organizational Behaviour		**7**
1.1	Introduction to OB, scope and importance	2
1.2	Individual behaviour, personality, perception	3
1.3	Attitudes, learning, emotional intelligence, stress	2
Module 2: Motivation, Leadership, and Communication		**7**
2.1	Motivation theories and applications	3
2.2	Leadership styles, power and politics	2
2.3	Communication process and barriers	2
Module 3: Group Behaviour and Team Dynamics		**7**
3.1	Groups, team formation, team effectiveness	3
3.2	Conflict, negotiation, decision-making	2
3.3	Engineering team case discussions	2
Module 4: Human Resources Management Functions		**8**
4.1	HRM concepts, HR planning, job analysis	2
4.2	Recruitment, selection, induction	2
4.3	Performance appraisal, compensation	2
4.4	Training, development, engagement	2
Module 5: Industrial Relations, HR Ethics, and Contemporary Issues		**7**
5.1	Industrial relations, trade unions, grievance handling	3
5.2	Labour laws and labour welfare	2
5.3	HR ethics, CSR, Industry 4.0 challenges	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Define Organizational Behaviour and state its importance in engineering organizations.
2. Explain the role of perception in individual behaviour at the workplace.
3. What is emotional intelligence? Why is it important for engineers?

Course Outcome 2 (CO2):

1. Explain Maslow's hierarchy of needs theory.
2. Distinguish between leadership and management.
3. List any three barriers to effective communication in organizations.

Course Outcome 3 (CO3):

1. What is a group? Differentiate between formal and informal groups.
2. Explain the stages of group development.
3. Define conflict and mention any two sources of conflict in organizations.

Course Outcome 4 (CO4):

1. Define Human Resource Management and state its objectives.
2. What is job analysis? Mention its components.
3. Explain the purpose of performance appraisal.

Course Outcome 5 (CO5)

1. What is industrial relations? State its importance.
2. Explain the concept of collective bargaining.
3. What is meant by ethics in human resource management?

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: **B24ME3P12**

Course Name: **ORGANIZATIONAL BEHAVIOUR & HUMAN RESOURCES MANAGEMENT**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Explain the role of perception in individual behaviour at the workplace.
2 What is emotional intelligence? Why is it important for engineers?
3 Explain Maslow's hierarchy of needs theory.
4 Distinguish between leadership and management.
5 Explain the stages of group development.
6 Define conflict and mention any two sources of conflict in organizations.
7 What is job analysis? Mention its components.
8 Explain the purpose of performance appraisal.
9 What is industrial relations? State its importance.
10 Explain the concept of collective bargaining.

PART B

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

Module 1

11 a. Explain the nature and scope of Organizational Behaviour (7 marks)

b. Discuss the factors influencing individual behaviour in engineering organizations. (7 marks)

OR

12 a. Explain personality and its determinants. (7 marks)

b. Discuss work stress and stress management techniques in industrial organizations. (7 marks)

Module 2

13 a. Explain Herzberg's two-factor theory of motivation. (7 marks)

b. Discuss motivation techniques suitable for manufacturing organizations. (7 marks)

OR

14 a. Explain different leadership styles with examples. (7 marks)

b. Describe the communication process and barriers to effective communication. (7 marks)

Module 3

15 a. Explain group behaviour and stages of group development. (7 marks)

b. Discuss the characteristics of effective teams in engineering organizations. (7 marks)

OR

16 a. Explain sources and types of conflict in organizations. (7 marks)

b. Describe conflict management and negotiation techniques. (7 marks)

Module 4

17 a. Explain human resource planning and job design. (7 marks)

b. Describe the recruitment and selection process. (7 marks)

OR

18 a. Explain performance appraisal methods. (7 marks)

b. Discuss training and development and its importance in manufacturing industries. (7 marks)

Module 5

19 a. Explain industrial relations and the role of trade unions. (7 marks)

b. Describe grievance handling procedures in organizations. (7 marks)

OR

20 a. Explain key provisions of labour legislation relevant to industries. (7 marks)

b. Discuss ethics, CSR & contemporary HR challenges in the context of Industry 4.0. (7 marks)

B24ME3P13	STRATEGIC MARKETING MANAGEMENT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

In an era of intense competition, rapid technological change, and evolving customer expectations, strategic marketing has become a critical capability for organizations across industries. This course on *Strategic Marketing Management* equips engineering students with the concepts, analytical tools, and decision frameworks required to understand markets, create customer value, and develop competitive marketing strategies. By integrating foundational marketing principles with strategic analysis, branding, innovation, digital marketing, and performance metrics, the course prepares students to apply marketing thinking in technology-driven environments and emerging market contexts. It builds a holistic understanding of how marketing strategy aligns with organizational goals and how modern tools & technologies shape strategic decision making.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain marketing management principles, customer behaviour, and STP frameworks to describe how firms create customer value and develop market orientation. (Cognitive Knowledge Level: Understand)
CO 2	Apply strategic market analysis tools such as SWOT, PESTLE, Five Forces, and portfolio matrices to assess competitive and environmental conditions. (Cognitive Knowledge Level: Apply)
CO 3	Discuss strategic decisions related to products, branding, and pricing by using innovation models, brand equity concepts, and fundamental pricing strategies. (Cognitive Knowledge Level: Understand)
CO 4	Describe strategic channel design, IMC elements, and digital marketing approaches, including the role of CRM and analytics in marketing decisions. (Cognitive Knowledge Level: Understand)
CO 5	Explain marketing implementation processes, performance measurement metrics, global marketing strategies, and emerging technologies in strategic marketing. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	2	1	1	0	1	2	1	0	2	3	2
CO 2	2	3	2	2	1	1	1	0	2	3	2
CO 3	1	2	2	1	2	2	1	1	2	3	1
CO 4	1	1	2	1	2	2	1	0	3	3	2
CO 5	1	2	2	1	1	2	2	1	2	3	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1 – Principles of Marketing Management & Market Orientation (7 Hours)

Introduction to marketing management: evolution, concepts, and relevance- Understanding customer needs, value creation, and customer satisfaction - Marketing environment analysis - micro and macro environments - Fundamentals of segmentation, targeting, and positioning (STP) - Consumer buying behaviour and B2B buying behaviour - Marketing mix: overview of 7Ps.

Module 2 – Strategic Market Analysis, Tools & Frameworks (7 Hours)

Role of strategic marketing in organizational strategy - Strategic marketing process and strategic fit - Customer analysis and insights for strategy - Environmental and competitive analysis: SWOT, PESTLE, Five Forces - Resource-based view and core competencies in marketing - Portfolio analysis tools: BCG matrix, GE/McKinsey matrix.

Module 3 – Strategic Product, Branding & Pricing Decisions (7 Hours)

New product development and product lifecycle strategies - Innovation strategies: disruptive innovation, open innovation, diffusion of innovation - Strategic brand management: brand identity, brand value chain, brand equity - Packaging and labelling strategy - Strategic pricing: objectives, approaches, value-based pricing, price discrimination - Competitive pricing strategies and pricing in digital markets.

Module 4 – Strategic Channels, Promotion & Digital Marketing (7 Hours)

Channel design and management; multi-channel and omni-channel strategies - Integrated marketing communication (IMC) strategy - Advertising, sales promotion, public relations, and personal selling strategy - Strategic digital marketing: SEO/SEM, content strategy, social media, mobile marketing - Customer relationship management (CRM) and data-driven marketing - Marketing automation and analytics.

Module 5 – Strategic Execution, Control & Emerging Technologies (8 Hours)

Marketing implementation and control systems - Marketing performance metrics, dashboards, and ROI in marketing - Strategic control systems and corrective action - Global marketing strategies: market entry, adaptation vs. standardization - Sustainability, ethics, and social responsibility in marketing strategy - Industry 4.0, IoT, AI, and platform business models in marketing strategy - Strategic marketing in emerging markets.

Textbooks

1. Ramaswamy V. S. & Namakumari S., *Marketing Management: Indian Context – Global Perspective*, SAGE India / Om Publications.
2. Harikumar P. N. & Sherlekar S. A., *Marketing Management*, Himalaya Publishing House.
3. Shajahan S., *Strategic Marketing: Text and Cases – Indian Perspective*, Viva Books.

References

1. David A. Aaker & Christine Moorman (Indian Adaptation), *Strategic Market Management*, Wiley India.

2. Jayant Isaac, *Strategic View of Marketing*, Himalaya Publishing House.
3. Narendra Singh, *Strategic Management & Marketing*, Himalaya Publishing House.
4. Neelamegham S., *Marketing in India: Texts and Cases*, Vikas Publishing.
5. Ambi M. G. Parameswaran & Isaac C. Jacob, *Strategic Brand Management (Indian Edition)*, Pearson India.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Evolution of marketing, core concepts, customer value; marketing orientations	2
1.2	Marketing environment (micro & macro), STP fundamentals	2
1.3	Consumer behaviour and B2B buying behaviour	2
1.4	Overview of marketing mix (7Ps), recap & discussion	1
	Module 2	**7**
2.1	Role of strategic marketing, strategic fit, customer analysis	2
2.2	SWOT & PESTLE analysis	2
2.3	Porter's Five Forces, RBV & VRIO	2
2.4	Portfolio tools: BCG, GE/McKinsey models	1
	Module 3	**7**
3.1	NPD and PLC strategies	2
3.2	Innovation strategies: disruptive, open innovation, diffusion	2
3.3	Branding: identity, equity (Aaker, Keller), brand value chain	2
3.4	Strategic pricing, digital pricing, competitive pricing	1
	Module 4	**7**
4.1	Channel design, multi-channel & omni-channel strategies	2
4.2	IMC: advertising, sales promotion, PR & personal selling	2
4.3	Digital marketing: SEO/SEM, content, social media, mobile marketing	2
4.4	CRM, analytics, marketing automation	1
	Module 5	**8**
5.1	Marketing implementation, control systems	2
5.2	Marketing metrics, dashboards, ROI; global marketing	2
5.3	Adaptation vs standardization, sustainability, ethics	2
5.4	Industry 4.0, IoT, AI, platforms; emerging markets (India focus)	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. What is customer lifetime value (CLV)? Why is it important?
2. What are the 7Ps of the marketing mix? State their relevance in services.
3. Discuss the STP process with suitable examples. Explain how segmentation, targeting, and positioning create competitive advantage.
4. Outline consumer buying behaviour using any consumer decision-making model. Illustrate how organizations use these insights for strategy.

Course Outcome 2 (CO2):

1. What is strategic fit? Why is it important in strategic marketing?
2. State the five forces in Porter's model.
3. Explain the BCG Matrix and GE/McKinsey Matrix. Compare the use of both tools in strategic portfolio planning.
4. Discuss the Resource-Based View (RBV) and VRIO framework. How does this approach help firms build sustainable competitive advantage?

Course Outcome 3 (CO3):

1. State the stages of the Product Life Cycle.
2. What is value-based pricing?
3. Explain the New Product Development (NPD) process with examples. Discuss the importance of innovation in sustaining competitive advantage.
4. Elaborate on pricing strategies—value-based, dynamic, competitive, and digital pricing. Discuss how pricing decisions influence brand positioning.

Course Outcome 4 (CO4):

1. Define CRM. Why is it essential in modern marketing?
2. What is content marketing?
3. Explain the elements of Integrated Marketing Communication (IMC). Design an IMC strategy for a new product launch.
4. Discuss digital marketing tools SEO, SEM, content strategy, social media, mobile marketing. Illustrate how firms create integrated digital campaigns.

Course Outcome 5 (CO5)

1. What is the role of ethics in marketing?
2. What are marketing dashboards?
3. Explain marketing implementation and control systems. Discuss how KPIs, dashboards, and ROI help track strategic performance.

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: **B24ME3P13**

Course Name: **STRATEGIC MARKETING MANAGEMENT**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Distinguish between consumer buying behaviour and B2B buying behaviour.
2. Define segmentation and list any four bases used in market segmentation.
3. Define core competencies. Give two examples.
4. State the five forces in Porter's model.
5. State the stages of the Product Life Cycle.
6. What is disruptive innovation? Give an example.
7. Explain omni-channel retailing with an example.
8. What is SEO? How is it different from SEM?
9. Define standardized vs. adapted global marketing strategies.
10. What are marketing dashboards?

PART B

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

Module 1

11. Explain the marketing environment in detail—micro and macro components—with examples. Analyse how environmental factors influence marketing decisions. (14 marks)

OR

12. Discuss the STP process with suitable examples. Explain how segmentation, targeting, and positioning create competitive advantage. (14 marks)

Module 2

13. Conduct a PESTLE and Porter's Five Forces analysis for any industry of your choice. Interpret how it influences strategic marketing decisions. (14 marks)

OR

14. Discuss the Resource-Based View (RBV) and VRIO framework. How does this approach help firms build sustainable competitive advantage? (14 marks)

Module 3

15. Explain the New Product Development (NPD) process with examples. Discuss the importance of innovation in sustaining competitive advantage. (14 marks)
16. Elaborate on pricing strategies—value-based, dynamic, competitive, and digital pricing. Discuss how pricing decisions influence brand positioning. (14 marks)

Module 4

17. Explain the elements of Integrated Marketing Communication (IMC). Design an IMC strategy for a new product launch. (14 marks)

OR

18. Discuss digital marketing tools—SEO, SEM, content strategy, social media, mobile marketing. Illustrate how firms create integrated digital campaigns. (14 marks)

Module 5

19. Discuss the impact of Industry 4.0 technologies (AI, big data, automation, platforms) on modern strategic marketing. Explain with suitable industry cases. (14 marks)

OR

20. Explain marketing implementation and control systems. Discuss how KPIs, dashboards, and ROI help track strategic performance. (14 marks)

B24ME3P14	OPERATIONS RESEARCH	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Operations Research (OR) is a scientific, data-driven approach to decision-making that equips engineers with analytical tools for optimizing complex systems. This course introduces students to mathematical modeling, resource allocation, and system performance analysis through Linear Programming, Transportation and Assignment models, Inventory and Queuing theory, Sequencing, Replacement strategies, and Game Theory. By integrating quantitative methods with real-world engineering scenarios, the course builds the competence required to design efficient solutions, support managerial decisions, and enhance productivity in industrial and service environments.

Prerequisites

Nil

Course Outcomes

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

CO 1	Model real-world engineering and management problems as Linear Programming Models and solve them using various methods. (Cognitive Knowledge Level: Apply)
CO 2	Develop and solve transportation and assignment models for optimal allocation of resources. (Cognitive Knowledge Level: Apply)
CO 3	Analyse inventory and queuing systems to determine optimal operating parameters. (Cognitive Knowledge Level: Analyse)
CO 4	Apply sequencing and replacement models to improve system productivity and cost-effectiveness. (Cognitive Knowledge Level: Apply)
CO 5	Analyse competitive decision-making strategies using concepts of game theory. (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	3	2	2	2	–	–	–	–	1	2
CO 2	3	3	2	2	2	–	–	–	–	1	2
CO 3	3	3	2	2	2	–	–	–	–	1	2
CO 4	3	3	3	2	2	–	–	–	–	1	3
CO 5	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			
Understand	40	30	30
Apply	60	40	40
Analyse		30	30
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1 – Introduction to Operations Research and Linear Programming (10 Hours)

Definition, scope, methodology of OR; characteristics of OR models; applications in engineering, management, logistics, and service systems - Formulation of Linear Programming Problems (LPP): Decision variables, objective function, constraints, assumptions of linearity, and typical model structures- Solution using Graphical method, Simplex method, Big-M method, Two-phase method- Duality concept, Primal–dual relationships, economic interpretation.

Module 2 – Transportation and Assignment Models (7 Hours)

Transportation model: Problem structure, formulation, balance considerations- Methods for initial feasible solution: NWCM, LCM, Vogel's Approximation- Optimality test (MODI method)- Special cases: unbalanced problems, degeneracy in transportation problems.
Assignment model: Formulation - Hungarian method- Variants: unbalanced problems, maximization cases, travelling salesman problem (TSP) through assignment reduction.

Module 3 – Inventory and Queuing Systems (7 Hours)

Inventory Control: Role of inventory, classification, associated costs -Deterministic models: EOQ Model (Basic Wilson's formula), EOQ with shortages, EOQ with quantity discounts - ABC analysis and multi-item inventory.
Queuing Theory: Basic structure of a queue, elements of a queuing system, Kendall's notation- Operating characteristics and classification of models - M/M/1 and M/M/c systems - applications in production and service systems.

Module 4 – Sequencing and Replacement Models (7 Hours)

Sequencing: Basic assumptions and types of sequencing problems - Sequencing *n* jobs on single and multiple machines - Johnson's algorithm for two and three machines - Graphical method for sequencing two jobs on *m* machines.
Replacement Models: Replacement of deteriorating capital equipment - Replacement by alternative equipment - Group and individual replacement policies.

Module 5 – Game Theory (5 Hours)

Nature, assumptions, and terminology of game theory- Two-person zero-sum games - Pure Strategy Games: Saddle point and dominance principles - Mixed Strategy Games: Games without saddle points, 2×2 matrix games (algebraic solution), m×2 matrix games (graphical method) -Reduction of game size using dominance and transformations.

Textbooks

1. Panneerselvam R., *Operations Research,* EEE Edition PHI
2. Kanti Swarup, P.K. Gupta & Man Mohan, *Operations Research*, Sultan Chand & Sons.
3. Kapoor V. K., *Operations Research Concepts, Problems. & Solutions*, Sultan Chand & Sons.

References

1. Hillier & Lieberman, *Introduction to Operations Research*, McGraw Hill.
2. H.A. Taha, *Operations Research: An Introduction*, Pearson Education.
3. Ravindran, Phillips & Solberg, *Operations Research: Principles and Practice*, Wiley.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**10**
1.1	Introduction, LPP Formulation, Graphical method	3
1.2	Simplex method, Big-M method, Two-phase method	6
1.3	Duality concept and interpretation.	1
	Module 2	**7**
2.1	Transportation model: Formulation, Methods for initial feasible solution: NWCM, LCM, Vogel's Approximation	3
2.2	Optimality test (MODI method)- degeneracy in transportation problems.	1
2.3	*Assignment model*: Formulation and Hungarian method, Problems	2
2.4	Maximization, traveling salesman problems.	1
	Module 3	**7**
3.1	*Inventory Control:* Inventory classification and associated costs	1
3.2	Deterministic models: EOQ, EOQ with shortages, and quantity discounts-	2
3.3	ABC analysis and multi-item inventory.	1
3.4	*Queuing Theory:* Basics, elements of a queuing system, Kendall's notation-Operating characteristics and classification of models	2
3.5	M/M/1 and M/M/c systems, applications in production and service systems.	1
	Module 4	**7**
4.1	*Sequencing:* Basic assumptions and types of sequencing problems - Sequencing *n* jobs on single and multiple machines.	2
4.2	Johnson's algorithm for two and three machines	1
4.3	Graphical method for sequencing two jobs on *m* machines.	1
4.4	*Replacement Models:* Replacement of deteriorating capital equipment -	1
4.5	Replacement by alternative equipment, Group and individual replacement policies.	2
	Module 5	**5**
5.1	Nature, assumptions, and terminology of game theory- Two-person zero-sum games.	1
5.2	Pure Strategy Games: Saddle point and dominance principles	1
5.3	Mixed Strategy Games: Games without saddle points, 2×2 matrix games (algebraic solution), m×2 matrix games (graphical method)	2
5.4	Reduction of game size using dominance and transformations	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Formulate a real-world engineering problem (production/scheduling/transport) as a Linear Programming Problem.
2. Solve the given LPP using the simplex method and interpret the result.
3. A manufacturing firm produces three products with resource constraints. Formulate the LPP, solve it using the simplex method, and discuss optimality.
4. Solve a Two-Phase/Big-M method problem and explain the role of artificial variables.

Course Outcome 2 (CO2):

1. Find an initial feasible solution using VAM for the given transportation table.
2. Solve an assignment problem using the Hungarian method.
3. Solve the complete transportation problem using VAM and MODI method and obtain the optimal cost.
4. Solve an unbalanced assignment problem (including dummy row/column) and compute total cost.

Course Outcome 3 (CO3):

1. Calculate EOQ, reorder level, and safety stock for the given inventory data.
2. Explain Kendall's notation and give examples of M/M/1 and M/M/c systems.
3. Solve an EOQ problem including shortages and compute optimum order quantity, maximum shortage, and TAC.
4. For an M/M/c system, compute probability of waiting, idle probabilities, and compare performance for different c.

Course Outcome 4 (CO4):

1. Apply Johnson's rule to sequence 3–4 jobs on two machines.
2. Calculate the replacement period for equipment with increasing running cost.
3. Sequence 5–6 jobs on two machines using Johnson's rule, draw the time chart, compute total elapsed time and idle time.
4. Solve a replacement problem involving a deteriorating asset with given maintenance costs and salvage values.

Course Outcome 5 (CO5)

1. Identify whether a saddle point exists for a 2×2 game.
2. Explain pure and mixed strategies with examples.
3. Solve a 2×2 game using the algebraic method and compute the value of the game.
4. Solve an m×n game using dominance and reduction, followed by mixed strategy or graphical solution.

MODEL QUESTION PAPER

QP CODE: Pages: 4

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIFTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: **B24ME3P14**

Course Name: **OPERATIONS RESEARCH**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain degeneracy and infeasibility.
2. What is the purpose of adding artificial variables in a simplex algorithm?
3. Solve the following using N-W corner rule.

	M_1	M_2	M_3	M_4	
W_1	2	2	2	1	3
W_2	10	8	5	4	7
W_3	7	6	6	8	5
	4	3	4	4	

4. Discuss the similarity between transportation problem and assignment problem.
5. Compute EOQ for a firm whose has an annual demand of 10,000 units/year, ordering cost ₹200 and holding cost ₹2/unit/year.
6. What is Kendall notation? Explain any one queuing model based on Kendall notation.
7. Differentiate between shortest processing time rule (SPT) and weighted shortest processing time rule (WSPT).
8. Distinguish between individual and group replacement.
9. Differentiate between pure strategy and mixed strategy.
10. Reduce the following 2×3 zero-sum game using dominance rules and obtain the reduced payoff matrix. Check whether any row or column can be eliminated through dominance, and write the resulting simplified game matrix.

	B_1	B_2	B_3
A_1	4	7	6
A_2	5	6	8

PART B

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

Module 1

11. A company manufactures two products, *X* and *Y by* using three machines *A*, *B*, and *C*. Machine *A* has 4 hours of capacity available during the coming week. Similarly, the available capacity of machines *B* and *C* during the coming week is 24 hours and 35 hours respectively. One unit of product *X* requires one hour of Machine *A*, 3 hours of machine *B* and 10 hours of machine *C*. Similarly, one unit of product *Y* requires 1 hour, 8 hour and 7 hours of machine *A*, *B* and *C* respectively. When one unit of *X* is sold in the market, it yields a profit of Rs. 5/- per product and that of *Y* is Rs. 7/- per unit. Solve the problem by using graphical method to find the optimal product mix. (14 marks)

OR

12. Solve the following:

Maximize $Z = 4x_1 + 5x_2 - 3x_3$

Subject to

$x_1 + x_2 + x_3 = 10$

$x_1 - x_2 \geq 1$

$2x_1 + 3x_2 + x_3 \leq 30$

$x_1 \geq 0, x_2 \geq 0, x_3 \geq 0$ (14 marks)

Module 2

13. Find the optimal solution for the following transportation problem. (14 marks)

	Market 1	Market 2	Market 3	Market 4	Market 5	Supply
Plant 1	10	2	16	14	10	300
Plant 2	6	18	12	13	16	500
Plant 3	8	4	14	12	10	825
Plant 4	14	22	20	8	18	375
Demand	350	400	250	150	400	

OR

14. A marketing manager has 5 salesman and 5 sales districts. Considering the capabilities of the salesman and the nature of districts, the marketing manager estimates that sales per month (In hundred rupees) for each salesman in each district would be as follows. Find the assignment of salesman to districts that will result in maximum sale.

	A	B	C	D	E
1	32	38	40	28	40
2	40	24	28	21	36
3	41	27	33	30	37
4	22	38	41	36	36
5	29	33	40	35	39

(14 marks**)**

Module 3

15. A manufacturing company has an annual demand of 12,000 units for one of its components. Each time an order is placed, the ordering cost incurred is ₹300. The purchase price of the item is ₹50 per unit, and the holding cost is 20% of the unit cost per year. The lead time for replenishment is 5 days, and the company operates 300 working days per year.

    (a) Compute the Economic Order Quantity (EOQ).
    (b) Determine the Reorder Level (ROL).
    (c) Calculate the Total Annual Cost (TAC) including ordering and carrying costs (exclude purchase cost).
    (d) Comment on how allowing shortages affects the total quantity ordered and inventory behaviour. (14 Marks)

OR

16. A service facility receives customers according to a Poisson arrival process at an average rate of $\lambda = 20$ customers per hour. The service mechanism is exponential with a service rate of $\mu = 15$ customers per hour per server. The facility operates with two parallel servers ($c = 2$), and customers are served on a first-come, first-served (FCFS) basis following an M/M/c queuing model with infinite queue capacity.

    (a) Compute the traffic intensity (ρ) of the system.
    (b) Determine the probability that an arriving customer has to wait for service.
    (c) Compute the following steady-state performance measures:
        L = average number of customers in the system
        Lq = average number of customers in the queue
        W = average time a customer spends in the system
        Wq = average waiting time in the queue
    (d) Based on the above results, interpret the performance of the system and comment on whether two servers are adequate for the given arrival and service rates. (14 Marks)

Module 4

17. A manufacturing workshop must process six jobs through two machines, Machine–1 (M_1) and Machine–2 (M2), in the same order M1 → M2. The processing times (in hours) for each job on both machines are given below:

	M_1	M_2
J1	7	9
J2	6	8
J3	8	7
J4	9	6
J5	5	4
J6	4	5

    a) Use Johnson's Rule to determine the optimal sequence that minimizes the total completion (makespan) time.
    b) Construct the detailed time chart for both machines based on the obtained sequence.

c) Compute the total elapsed time (makespan) for completing all six jobs.
d) Calculate the idle time for Machine–1 and Machine–2 separately.
e) Comment briefly on how Johnson's Rule helps in improving production scheduling efficiency. (14 marks)

OR

18. Machine 'A' costs Rs. 9000 and its annual operating cost is Rs.200 for the first year and then increased by Rs. 2000 every year. Determine the optimum replacement policy. Machine 'B costs Rs. 10,000 and its annual operating cost is Rs. 400 for the first year and then increased by Rs. 800 every year. You now own a machine A which one year old. Should you replace it with B? if so, when? (14 marks)

Module 5

19. A company is evaluating two strategic options, Strategy A_1 and Strategy A_2, against three possible competitive responses from a rival firm, B_1, B_2, and B_3. The corresponding payoff matrix (payoffs to Player A) is given below:

	B_1	B_2	B_3
A_1	4	2	6
A_2	3	5	1

(a) Reduce the payoff table, if possible, using dominance.
(b) Using the graphical method, solve the reduced 2×3 game to determine:
(i) the optimal mixed strategy for Player A
(ii) the optimal mixed strategy for Player B
(iii) the value of the game
(c) Draw and label the relevant graph clearly to show the intersection point used to solve the game.

OR

20. A firm (Player A) is competing with a rival firm (Player B) in launching two alternative marketing strategies. The expected payoff (in units of market advantage) to Firm A for each combination of strategies is shown in the following 2×2 zero-sum game:

	B_1	B_2
A_1	2	8
A_2	6	4

(a) Determine whether a saddle point exists for the game.
(b) Solve the game using the algebraic mixed-strategy method.
(i) Compute the optimal mixed strategy for Player A
(ii) Compute the optimal mixed strategy for Player B
(c) Compute the value of the game and explain its meaning in the context of competitive decision-making.
(d) Comment on which player has an advantage and how the mixed strategies balance risk.

B24ME3P15	OBJECT ORIENTED PROGRAMMING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces students to object-oriented design and its practical application in Python. It covers OOP principles (abstraction, encapsulation, inheritance, polymorphism), Python-specific class features, advanced language constructs (descriptors, magic methods, iterators/generators), design patterns and testing/serialization techniques. Through lectures and assignments students will design, implement and test reusable, well-documented Python software suitable for engineering applications (e.g., inventory, student records, simple data-processing pipelines using NumPy/Pandas)

Prerequisites

Fundamental Python Programming Skills

Course Outcomes

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

CO 1	Explain the principles of object-oriented design and represent class relationships using UML. (Cognitive Knowledge Level: Understand)
CO 2	Develop and use Python classes, modules, and packages by applying appropriate conventions for defining attributes and methods. (Cognitive Knowledge Level: Apply)
CO 3	Construct and implement class hierarchies by applying inheritance, polymorphism, and exception handling mechanisms. (Cognitive Knowledge Level: Apply)
CO 4	Make use of advanced Python OOP features (properties, descriptors, magic methods) and apply common design patterns to small projects. (Cognitive Knowledge Level: Apply)
CO 5	Apply unit testing techniques, object serialization, and integration of OOP designs with NumPy/Pandas or file I/O to solve real-world problems. (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	1	1						1	
CO 2	3	2	1	1	2					1	
CO 3	3	3	2	1	2					1	
CO 4	3	3	2	1	3					2	
CO 5	3	2	1	2	3					2	1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	10	10
Understand	40	30	30
Apply	20	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Introduction to Object-Oriented Programming Concepts (6 hours)

Introduction to object-oriented programming paradigm and its advantages in engineering applications. Fundamental object-oriented concepts: class, object, attributes, methods, and instances. Abstraction and encapsulation with relevance to mechanical components and systems. Public and private data members. Introduction to UML class diagrams for modeling engineering systems. Composition versus inheritance decision-making framework. Introduction to polymorphism and duck typing. Simple mechanical system case study with basic UML modeling exercise.

Module 2: Class Construction and Modular Programming in Python (7 hours)

Defining and instantiating classes in Python. Constructors using init, instance attributes, and use of self. Class variables and instance variables. Method types including instance methods, class methods, and static methods. Access control, data hiding, and Python naming conventions. Property decorators for controlled attribute access and validation. Organization of code into modules and packages. Exercise involving implementation of simple class hierarchies representing mechanical components or subsystems.

Module 3: Inheritance, Polymorphism, and Exception Handling in Engineering Systems (8 hours)

Single inheritance applied to mechanical assemblies. Use of super() for method resolution. Method overriding and dynamic dispatch. Introduction to abstract base classes and interfaces using the abc module. Polymorphism and duck typing in Python. Custom exception classes and structured exception handling for engineering data and simulations. Exception hierarchies for domain-specific errors. Exercise on designing a reusable class hierarchy with abstract base classes and exception handling for mechanical analysis tasks.

Module 4: Advanced OOP Features and Design Patterns for Mechanical Applications (7 hours)

Properties and descriptors using getter and setter decorators. Operator overloading with magic methods: add, sub, mul, eq, lt, str, repr. Generators and comprehensions for processing engineering datasets. Singleton design pattern: implementation and use cases for configuration management. Strategy design pattern: multiple algorithms for control strategies and data processing. Integration of advanced features in a mini-project involving mechanical system component or controller modeling.

Module 5: Testing, Serialization, and Engineering Case Study (8 hours)

Introduction to unit testing and Test-Driven Development using pytest. Test fixtures, assertions, and edge case testing for mechanical simulations. Object serialization using JSON and pickle. Serialization of complex object hierarchies and mechanical system configurations. Comprehensive case study: Multi-zone HVAC system design with components, inheritance hierarchy, abstract base classes, control strategies using design patterns, custom exception handling, sensor validation, configuration management using Singleton, unit tests with pytest, and system state persistence using serialization. Integration of all OOP concepts through realistic engineering application.

Text Books

1. Dusty Phillips, Python 3 Object-Oriented Programming, PACKT publishing, 3rd Edition, 2018.
2. Luciano Ramalho, Fluent Python: Clear, Concise, and Effective Programming, O'Reilly Media, 2nd Edition, 2022
3. Steven F. Lott & Dusty Phillips, Python Object-Oriented Programming - Fourth Edition: Build robust and maintainable object-oriented Python applications and libraries, Packt Publishing, 4th Edition, 2021

Reference Books

1. Irv Kalb, Object-Oriented Python: Master OOP by Building Games and GUIs, 1st Edition, No Starch Press, 2022
2. Reema Thareja , python programming: using problem solving approach, Oxford University Press, 1st Edition, 2017

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
Module 1: Introduction to Object-Oriented Programming Concepts		**6**
1.1	Review of procedural paradigms; need for OOP; software design motivation	1
1.2	Class, object, attribute, method, interface	1
1.3	Abstraction and Encapsulation; public vs private data; information hiding	1
1.4	UML class diagrams; notation; representing relationships	1
1.5	Composition, aggregation, inheritance, polymorphism, duck typing – conceptual understanding	1
1.6	Simple design case study and UML modelling exercise	1
Module 2: Class Construction and Modular Programming in Python		**7**
2.1	Defining and Instantiating Classes- Syntax; object creation	1
2.2	__init__, Instance Attributes, self Attribute initialization; design decisions	1
2.3	Class variables vs instance variables – differences and examples	1
2.4	Method types – instance, class (@classmethod), static (@staticmethod)	1
2.5	Access modifiers & naming conventions; name-mangling, data hiding	1
2.6	Organization of code into modules and packages; folder structure; imports	1
2.7	Simple class hierarchies; composition problems	1
Module 3: Inheritance, Polymorphism, and Exception Handling in Engineering Systems		**8**
3.1	Single and multiple inheritance; use of super()	1

3.2	Method Overriding & Dynamic Dispatch	1
3.3	Abstract classes and interfaces (abc module)	1
3.4	Polymorphism & Duck Typing in Python	1
3.5	Custom exception classes; structured exception handling	2
3.6	Exercise: Build reusable class hierarchy with exceptions	2
Module 4: Advanced OOP Features and Design Patterns for Mechanical Applications		**7**
4.1	Properties and descriptors; getter/setter decorators; custom descriptors	2
4.2	Operator overloading; magic methods (__str__, __len__, etc.)	1
4.3	Iterators, generators; iterator protocol; generator functions	1
4.4	Introduction to design patterns – Singleton, Strategy, Observer, Decorator	1
4.5	Implementing patterns in Python – class and function decorators, mixins	1
4.6	Small OOP Pattern-based Project (Inventory / student record)	1
Module 5: Testing, Serialization, and Engineering Case Study		**8**
5.1	Unit testing and TDD – unittest, pytest, assertions	2
5.2	Mocking and test coverage basics	2
5.3	Serialization – pickle, json, custom serializers	2
5.4	Case study: OOP integration with NumPy/Pandas or file I/O	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Draw a UML class diagram for a library management system that includes Book, Member, Loan classes and specify relationships.
2. Explain the difference between abstraction and encapsulation with appropriate Python code fragments. Why are both critical in large-scale software design?
3. Given a procedural implementation of a student-record management system, identify three limitations of the procedural approach and rewrite the conceptual model in terms of classes and objects.

Course Outcome 2 (CO2):

1. Implement a Matrix class with instance and class variables; show how to use @classmethod and @staticmethod.
2. Create a small package structure for a library management system including modules such as *models.py, utils.py, and database.py.* Show import statements and how the modules interact.
3. Implement a Python class *Employee* where salary is a private attribute. Provide getter and setter methods using naming conventions for data hiding. Explain how name-mangling

works.

Course Outcome 3 (CO3):

1. Design an inheritance hierarchy for vehicles including Vehicle, Car, Truck. Demonstrate method overriding and use of super(). Implement custom exception classes for input validation in the above hierarchy.
2. Implement an abstract class Sensor using the abc module with abstract methods read() and calibrate(). Then derive two concrete sensors TempSensor and PressureSensor. Show how polymorphism allows uniform handling.
3. Define a custom exception InvalidGradeError for a grading system. Write a function that raises this exception for invalid marks and handles it gracefully using try–except–else–finally.

Course Outcome 4 (CO4):

1. Create a descriptor class *PositiveValue* that ensures an attribute is always stored as a non-negative number. Use this descriptor in a *Product* class for *price* and *stock*.
2. Implement a *Vector* class with *__add__*, *__len__*, and *__str__*. Show two examples demonstrating operator overloading and how magic methods improve usability.
3. Implement the Strategy Pattern for a payment system supporting *CreditCardPayment*, *UPIPayment*, and *WalletPayment*. Demonstrate how strategies can be switched at runtime.

Course Outcome 5 (CO5)

1. Write unit tests (using pytest) for a class that implements a small inventory. Show at least three test cases including mocking file I/O. Serialize a class instance to JSON and pickle; discuss advantages and security considerations
2. Demonstrate serializing and deserializing an object of class *Student* using both *pickle* and *json*. Discuss when *JSON* is preferable over *pickle*.
3. Given a CSV file of sensor readings, write a Python class *SensorData* that loads the data using Pandas, processes it, and serializes results to JSON. Describe how OOP improves modularity in this workflow.

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: **B24ME3P15**

Course Name: **OBJECT ORIENTED PROGRAMMING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1		What is the difference between *procedural programming* and *object-oriented programming*? Give one simple example for each.
2		Define class, object, and method. Illustrate with a small Python snippet
3		Explain the purpose of the __init__ method in Python. How is it different from a normal method?
4		Differentiate between instance variables and class variables using a short code example.
5		What is method overriding? Give a simple example demonstrating dynamic dispatch.
6		Write a short note on custom exception classes in Python. Why are they useful?
7		What are magic methods in Python? Give two commonly used magic methods and their purpose.
8		Define the Strategy Design Pattern. Give one real-world example where it can be applied.
9		What is unit testing? How does Test-Driven Development (TDD) improve code quality?
10		List two differences between JSON serialization and pickle serialization in Python.

PART B

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

Module 1

11	a.	Explain abstraction and encapsulation in object-oriented programming with simple Python examples.	(7 marks)
	b.	Draw a UML class diagram for a Student–Course Registration System.	(7 marks)

OR

12	a.	Discuss the differences between composition and aggregation with examples.	

(7 marks)

b. Identify four classes for a library catalog system with attributes and methods. (7 marks)

Module II

13 a Write a Python class Employee demonstrating instance attributes, class attributes, @classmethod, and @staticmethod. (7 marks)

b Explain how modules and packages improve code organization with an example folder structure. (7 marks)

OR

14 a. Describe access modifiers in Python with examples. (7 marks)

b. Implement a simple class hierarchy using composition (Car contains an Engine). (7 marks)

Module III

15 a. Explain method overriding and dynamic dispatch with an example. (7 marks)

b. Write a custom exception InvalidAgeError and show its handling. (7 marks)

OR

16 a. Describe multiple inheritance in Python with one advantage and one disadvantage. (7 marks)

b. Create an abstract class Shape (abc) with area() and two subclasses. (7 marks)

Module IV

17 a. Explain @property with an example. (7 marks)

b. Implement operator overloading for + in a Vector class. (7 marks)

OR

18 a. Describe the Observer pattern with a real-world example. (7 marks)

b. Write an iterator class for even numbers up to a limit. (7 marks)

Module V

19 a. Explain the steps of TDD with an illustration. (7 marks)

b. Serialize and deserialize a dictionary using JSON. (7 marks)

OR

20 a. What is mocking? Give an example scenario. (7 marks)

b. Write a DataHandler class that loads a CSV file with Pandas and prints row count. (7 marks)

B24ME3P16	DATA ANALYTICS FOR ENGINEERS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Data Analytics for Engineers equips students with essential concepts and methodologies for extracting meaningful insights from engineering data to support effective decision-making. The course establishes a strong foundation in statistical thinking, data acquisition and processing, visualization techniques, and introductory predictive modeling, enabling learners to analyze and interpret real-world engineering datasets. Emphasis is placed on systematic analytical workflows, the use of contemporary tools, and hands-on case studies drawn from mechanical and interdisciplinary engineering applications. By developing proficiency in data management, descriptive and probabilistic analysis, and fundamental machine learning approaches, the course lays a solid groundwork for advanced learning in artificial intelligence, machine learning, and data-driven engineering systems.

Prerequisites

Nil

Course Outcomes

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

CO 1	Outline engineering data types, data sources, analytics workflows, and roles of data professionals. (Cognitive Knowledge Level: Understand)
CO 2	Explain descriptive statistics, probability concepts, sampling, and inference methods for understanding engineering datasets. (Cognitive Knowledge Level: Understand)
CO 3	Apply data preprocessing, visualization techniques, time-series concepts, and exploratory data analysis to engineering datasets. (Cognitive Knowledge Level: Apply)
CO 4	Apply basic regression, classification, clustering, dimensionality reduction, and model evaluation techniques for introductory predictive modelling. (Cognitive Knowledge Level: Apply)
CO 5	Choose appropriate data analytics methods for engineering case studies. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	1	1	–	–	–	1	–	1
CO2	3	3	1	2	1	–	–	–	1	–	2
CO3	2	3	2	3	3	–	–	1	1	–	2
CO4	2	3	2	3	3	–	–	1	1	1	2
CO5	2	3	3	3	3	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	30
Understand	60	40	40
Apply		40	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1 Introduction to Data Analytics (6 hours)

Introduction to data analysis – data types, data sources, characteristics – data acquisition, web scrapping – data quality – data storage formats – data analytics workflow: collection, cleaning, transformation, visualization – types of analytics: descriptive, diagnostic, predictive, prescriptive – statistics vs data analytics – roles and responsibilities of data professionals – ethics in data usage – significance and role of data analytics in mechanical engineering systems.

MODULE 2 Descriptive Analytics and Statistical Foundations (8 hours)

Measures of central tendency – measures of dispersion – skewness and kurtosis – frequency distributions – visual tools – correlation and covariance – basics of probability – random variables – probability distributions: Normal, Binomial, Poisson – population and samples – sampling methods – sampling distribution – central limit theorem – estimators – confidence intervals – hypothesis testing – statistical learning: prediction, inference.

MODULE 3 Data Processing and Visualization (8 hours)

Data preprocessing – missing data, outlier detection, noise handling, feature scaling, normalization – visualization tools: Excel, Tableau, Power BI – Python-based processing and visualization – time-series concepts: trend, patterns, noise, moving averages – exploratory data analysis (EDA) – training–testing split – resampling methods – cross-validation – hyperparameter tuning – case studies using datasets.

MODULE 4 Predictive Modelling Basics (7 hours)

Supervised and unsupervised learning – simple linear regression – least-squares fit – error measures – correlation and regression analysis – concepts of classification, association, clustering – overview of regression, classification, association, clustering techniques – model evaluation: accuracy, confusion matrix, ROC curve – feature selection – dimensionality reduction – regularization/shrinkage.

MODULE 5 Engineering Applications (7 hours)

Applications in engineering systems – case studies: supply chain analytics, environmental prediction, energy consumption analysis, predictive maintenance, material characteristic prediction, process optimization, quality control, structural analysis – business analytics – text analytics – risk analysis – marketing analytics – sentiment analysis (concepts) – mini-project with complete analytics workflow.

Text Books

1. Gareth James, Daniela Witten, Trevor Hastie & Robert Tibshirani, *An Introduction to Statistical Learning: With Applications in R*, Springer.
2. Anil Maheshwari, *Data Analytics*, McGraw Hill Education.

Reference Books

1. Lihui Wang, *Data Analytics for Intelligent Manufacturing Systems*, Springer.

2. Douglas C. Montgomery & George C. Runger, *Applied Statistics and Probability for Engineers*, Wiley.
3. Daniela Galatro & Stephen Dawe, *Data Analytics for Process Engineers: Prediction, Control and Optimization,* Morgan & Claypool Publishers.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1: Introduction to Data Analytics	**6**
1.1	Introduction to data analysis; data types; data sources; characteristics; data acquisition; web scrapping; data quality; data storage formats.	1
1.2	Data analytics workflow: collection, cleaning, transformation, visualization.	2
1.3	Types of analytics: descriptive, diagnostic, predictive, prescriptive.	1
1.4	Statistics vs data analytics; roles and responsibilities of data professionals; ethics in data usage.	1
1.5	Significance and role of data analytics in mechanical engineering systems.	1
	Module 2: Descriptive Analytics and Statistical Foundations	**8**
2.1	Measures of central tendency; measures of dispersion; skewness and kurtosis.	1
2.2	Frequency distributions; visual tools; correlation and covariance.	1
2.3	Basics of probability; random variables; probability distributions: Normal, Binomial, Poisson.	2
2.4	Population and samples; sampling methods; sampling distribution.	1
2.5	Central limit theorem, confidence intervals.	1
2.6	Hypothesis testing.	1
2.7	Statistical Learning; prediction and inference.	1
	Module 3: Data Processing and Visualization	**8**
3.1	Data preprocessing – missing data, outlier detection, noise handling.	1
3.2	Feature scaling, normalization	1
3.3	Visualization tools (Excel, Tableau, Power BI); Python-based processing and visualization;	2
3.4	Time-series concepts – trend, patterns, noise, moving averages;	1
3.5	Exploratory data analysis (EDA); training–testing split;	1
3.6	Resampling methods; cross-validation; hyperparameter tuning. Case studies using dataset.	2
	Module 4: Predictive Modelling Basics	**7**
4.1	Supervised and unsupervised learning; simple linear regression; least-squares fit; error measures.	1
4.2	Correlation and regression analysis; concepts of classification, association and clustering/	2
4.3	Overview of regression, classification, association and clustering techniques.	1

4.4	Model evaluation – accuracy, confusion matrix, ROC curve.	1
4.5	Feature selection; dimensionality reduction; regularization/shrinkage.	2
	Module 5: Engineering Applications	**7**
5.1	Applications in engineering systems; Supply Chain Analytics	2
5.2	Environmental prediction, energy consumption analysis.	1
5.3	Predictive maintenance, material characteristic prediction.	1
5.4	Process optimization, quality control, structural analysis.	1
5.5	Business analytics; text analytics.	1
5.6	Risk analysis; marketing analytics; sentiment analysis (concepts).	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Define engineering data types and give one example for each.
2. Explain the steps involved in a basic data analytics workflow.
3. Describe the role of a data analyst, data scientist, and data engineer.
4. Discuss how data analytics supports decision-making in mechanical engineering.

Course Outcome 2 (CO2):

1. Calculate the mean, median, mode, and standard deviation for a given dataset.
2. Explain the difference between a population and a sample with examples.
3. Interpret a histogram or box plot and comment on data distribution.
4. Apply hypothesis testing or confidence intervals to draw an inference from sample data.

Course Outcome 3 (CO3):

1. Apply missing value handling and normalization to a sample dataset.
2. Generate a simple visualization (line plot, bar chart, or scatter plot) and interpret the results.
3. Perform an exploratory data analysis (EDA) and summarize the observations.
4. Analyze a time-series dataset using moving averages to identify trends.

Course Outcome 4 (CO4):

1. Fit a simple linear regression model to a dataset and interpret the slope and intercept.
2. Apply classification or clustering concepts to categorize or group engineering data.
3. Evaluate a model using accuracy, confusion matrix, or ROC curve.
4. Use dimensionality reduction or regularization concepts to improve a model.

Course Outcome 5 (CO5)

1 Analyze a mechanical or thermal dataset and identify key patterns.
2 Apply analytics techniques to evaluate process performance or product quality.
3 Interpret results from a predictive maintenance case study.
4 Demonstrate a complete analytics workflow on an engineering dataset.

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: **B24ME3P16**

Course Name: **DATA ANALYTICS FOR ENGINEERS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1	What are the main steps in a data analytics workflow?
2	What is the difference between descriptive and predictive analytics?
3	What does the standard deviation indicate about a dataset?
4	What is a probability distribution? Give one example.
5	What is normalization in data preprocessing?
6	What is the purpose of Exploratory Data Analysis (EDA)?
7	What does a linear regression model represent?
8	What information does a confusion matrix provide?
9	What is the purpose of predictive maintenance in engineering systems?
10	Give one example of how data analytics is used in manufacturing.

PART B

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

Module 1

11 Explain the different types of engineering data and describe how data analytics contributes to decision-making in mechanical engineering systems.

(14 marks)

OR

12 Discuss and compare the various roles of data professionals.

(14 marks)

Module 2

13 Describe the measures of central tendency and dispersion, and explain how they help in understanding the characteristics of engineering datasets.

(14 marks)

OR

14 Explain probability distributions and sampling methods, and discuss how statistical inference supports engineering problem-solving. (14 marks)

Module 3

15 Explain the key steps involved in data preprocessing. (14 marks)

OR

16 Describe time-series analysis techniques such as trend identification and moving averages, and explain their relevance in engineering applications. (14 marks)

Module 4

17 Discuss the concepts of supervised and unsupervised learning and explain their roles in predictive analytics. (14 marks)

OR

18 Explain linear regression, classification, and clustering methods. (14 marks)

Module 5

19 Discuss the applications of data analytics in supply chain management, using suitable examples. (14 marks)

OR

20 Explain how a complete data analytics workflow can be applied to an engineering case study, from preprocessing to model interpretation and reporting. (14 marks)

B24ME3P17	BASICS OF ARDUINO PROGRAMMING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course provides a comprehensive introduction to programming microcontrollers with a practical focus on the Arduino platform. Students learn the fundamentals of microcontroller architecture, programming concepts, digital and analog interfacing, sensor data acquisition, and serial communication protocols. Through hands-on labs, learners work with common sensors, actuators, and motors to develop functional embedded systems. The course also covers essential concepts in signal processing, timing, and basic feedback control, enabling students to design simple automation and control applications using microcontroller-based hardware.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the architecture, components, and programming environments of microcontroller-based development boards, with emphasis on Arduino. (Cognitive Knowledge Level: Understand)
CO 2	Develop structured and logical Arduino programs using variables, conditionals, loops, operators, and modular functions. (Cognitive Knowledge Level: Apply)
CO 3	Equip students with the skills to interface digital and analog devices and communicate with sensors and peripherals using standard serial protocols. (Cognitive Knowledge Level: Apply)
CO 4	Acquire, process, filter, and interpret real-time data from various sensors using analog inputs, mapping, and timed sampling techniques. (Cognitive Knowledge Level: Apply)
CO 5	Control motors and actuators, measure motion parameters, and apply basic feedback control concepts in automation systems. (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	1		2	1			1		1
CO 2	3	3	2	2	3				2		2
CO 3	3	2	3	2	3	1		1	2		2
CO 4	3	3	2	3	3				2		3
CO 5	2	3	3	2	3	1		1	2	1	3

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	10	10
Understand	60	30	30
Apply		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
Self-Study (Capstone project) : 15 marks

(Student shall submit a project encapsulating various aspects learned from the course for evaluation)

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1 (7 Hours)

Basics of Microcontrollers: Features, Types and Classifications, Basic hardware elements, Microcontrollers Vs Microprocessors, Uses and limitations. Common Development boards.

Arduino: Basic components: Power supply, Power connections, Analog inputs, Digital connections, Microcontroller and other components, Origins, Arduino family. Programming environments: Arduino IDE (Embedded C), Arduino Lab (MicroPython), Running and Compiling Codes, Best practices for using Editors.

MODULE 2 (7 Hours)

Programming review: Basics, Variables and Data Types, storing measurements, Storing constants like safety limits and system thresholds.

Operators and Expressions: Arithmetic and logical, Calculating time difference between two events. Conditional Statements (if/else): Decision-making, Programming a threshold alarm (IF reading>threshold), Switch-case Statements: Multi-mode systems, Looping (for/while): Repetitive actions. Functions: Writing reusable, modular code blocks.

MODULE 3 (7 Hours)

Basic Electronics, Digital Signals, Digital Output: pinMode() and digitalWrite(), Turn on an LED, Digital Input (Buttons): Switches for sensing/triggers, Read a Push button. Timing with delay().

Analog Input/Output: Analog signal, Pulse width modulation, read an analog signal (potentiometer), Dim an LED.

Serial Communication Protocols: Inter-Integrated Circuit (I2C), Serial Peripheral Interface (SPI), Universal Asynchronous Receiver-Transmitter (UART), Read I2C Sensor value, Debugging and basic feedback, Printing the state (Open/Closed) of a simulated limit switch.

MODULE 4 (7 Hours)

Analog Data Acquisition, Analog Input: Reading the ADC, Reading a Potentiometer as a proxy for displacement or angle, The map() Function: Mapping potentiometer readings to a 0-180 degree range,

Temperature Sensing: TMP36 or DS18B20 Creating a real-time temperature logging system. Proximity/Distance Sensing: Ultrasonic Sensor (HC-SR04), Measuring part distance on a simulated conveyor belt.
Signal Filtering: Moving Average filter, Comparing raw vs. filtered distance readings for stability.
Sampling and DAQ Basics: Timed readings, Creating a consistent data collection loop.

MODULE 5 (7 Hours)

Actuation and Basic Control, DC Motor Control: H-Bridge Drivers, Controlling the direction of rotation, Variable DC Motor Speed: PWM (AnalogWrite), Controlling motor speed based on a potentiometer set-point.

Servo Motor Control: Servo Library for angular position, Programming an actuator for valve opening/closing.

Encoder/Tachometer Basics: Reading RPM, Calculating the RPM of a spinning disc based on frequency. Fundamentals of Feedback Control.

Text Books

1. Simon Monk, *Programming Arduino*, McGraw-Hill, 2nd ed., 2012.

Reference Books

1. Simon Monk, *Programming Arduino Next Steps*, McGraw-Hill, 2nd ed., 2012
2. Massimo Banzi, Michael Shiloh, *Getting Started with Arduino,* Make Community, 3rd ed., 2014
3. Michael Margolis, Brian Jepson, *Arduino Cookbook*, O'Reilly, 3rd ed., 2020
4. John-David Warren, Josh Adams, and Harald, *Arduino Robotics*, Apress, 1st ed., 2011

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Intro to Microcontrollers: Features, types, classifications, hardware elements	1
1.2	MCU vs MPU: Differences, applications, pros/cons	1
1.3	Development Boards: Arduino, ESP, STM, Raspberry Pi Pico	1
1.4	Arduino Hardware: Power, analog/digital pins, USB chip, regulators	1
1.5	Arduino Programming Environments: Arduino IDE, MicroPython, compiling, uploading	2
1.6	Intro to Microcontrollers: Features, types, classifications, hardware elements	1
	Module 2	**7**
2.1	Programming Basics: Variables, data types, constants, thresholds	1
2.2	Operators & Expressions: Arithmetic, logical, time difference	2
2.3	Conditional Statements: if/else, threshold alarm, switch-case	2
2.4	Looping: for, while loops	1
2.5	Functions: Modular code design, arguments, returns	1
	Module 3	**7**
3.1	Basics of Electronics: Voltage/current, logic levels, pull-up/pull-down	2
3.2	Digital I/O: pinMode, digitalWrite, buttons	2
3.3	Analog I/O & PWM: ADC, analogRead, PWM dimming	2
3.5	Serial Communication: UART, I2C, SPI, debugging	1
	Module 4	**7**
4.1	Analog Data Acquisition: ADC concepts, sampling	1
4.2	map() Function: Scaling ADC → degrees	1

4.3	Temperature Sensing: TMP36, DS18B20	2
4.4	Ultrasonic Distance: HC-SR04, TOF basics	2
4.5	Filtering & Timed Sampling: Moving average, millis() timing	1
	Module 5	**8**
5.1	DC Motor Control: H-Bridge, forward/backward	2
5.2	PWM Speed Control: analogWrite, speed control	2
5.3	Servo Motor Control: Servo library, angle control	2
5.4	Encoders & RPM: Pulse counting, RPM calculation	1
5.5	Basic Feedback Control: Open/closed loop, set-point	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the differences between a microcontroller and a microprocessor with respect to architecture, memory organization, and typical applications.
2. Describe the major hardware components of an Arduino Uno board and explain the function of each.
3. What are the key features of microcontrollers? Classify microcontrollers based on architecture and give suitable examples.

Course Outcome 2 (CO2):

1. Define variables and data types in Arduino programming. How are constants used in safety-critical embedded applications?
2. Explain the role of conditional statements and loops in embedded programs. Illustrate with examples using Arduino syntax.
3. What is the importance of modular programming? Describe how functions improve code readability and reusability in microcontroller applications.

Course Outcome 3 (CO3):

1. Distinguish between digital and analog signals. How are digital I/O functions (pinMode(), digitalWrite(), digitalRead()) used in Arduino?
2. Explain the working principle of PWM. How is PWM used to control brightness or speed in embedded systems?
3. Compare UART, I2C, and SPI serial communication protocols in terms of data format, wiring requirements, and applications.

Course Outcome 4 (CO4):

1. Describe how the Arduino ADC works. What factors affect the accuracy of analog data

acquisition?

2. Explain the working principles of the TMP36/DS18B20 temperature sensors and outline steps to implement a temperature logging system.
3. What is a moving average filter? Explain its importance in sensor data processing with an example.

Course Outcome 5 (CO5)

1. Explain the construction and working of an H-bridge motor driver. How does it enable bidirectional control of a DC motor?
2. Discuss how PWM is used to control the speed of a DC motor and the position of a servo motor.
3. What is feedback control? Explain with an example how sensors and actuators work together in a basic closed-loop 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: **B24ME3P17**

Course Name: **BASICS OF ARDUINO PROGRAMMING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1	What is a microcontroller? List any two key features.
2	Name any two Arduino programming environments and their primary programming languages
3	What is the purpose of a constant in embedded programming?
4	Differentiate between a "for loop" and a "while loop" in Arduino programs.
5	What is PWM and why is it used in embedded systems?
6	Write the purpose of the functions pinMode() and digitalRead() in Arduino.
7	What does the map() function do in Arduino?
8	Mention any two applications of the HC-SR04 ultrasonic sensor.
9	What is the role of an H-bridge in motor control?
10	Define RPM and explain how an encoder helps measure it.

PART B

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

Module 1

11	Discuss the architecture and classification of microcontrollers with suitable examples. (14 marks)

OR

12	Explain the hardware components of the Arduino Uno board in detail, including power supply, microcontroller, and I/O pins. (14 marks)

Module 2

13 Write an Arduino program using if-else and switch-case statements to operate a multi-mode alarm system based on sensor thresholds. Explain the logic used. (14 marks)

OR

14 Describe the role of functions in modular programming. Write a sample Arduino function to read and average sensor data over multiple samples. (14 marks)

Module 3

15 Compare the UART, SPI, and I2C communication protocols in terms of hardware connections, speed, and typical applications. (14 marks)

OR

16 Explain the working of PWM signals. How can PWM be used to control LED brightness and DC motor speed? Include code snippets. (14 marks)

Module 4

17 Explain the working principle and interfacing of the TMP36 temperature sensor with Arduino. How would you implement temperature logging with timestamped data? (14 marks)

OR

18 Describe the ultrasonic sensor HC-SR04 operation and its use in measuring distance on a moving conveyor. How would you filter the sensor data to improve accuracy? (14 marks)

Module 5

19 Describe the operation of an H-bridge motor driver circuit and explain how it allows bidirectional control of a DC motor. Include typical interfacing methods. (14 marks)

OR

20 What is feedback control? Explain with a block diagram how an encoder-based RPM measurement system can be integrated into a closed-loop speed control system. (14 marks)

B24ME3L06	ROBOTICS AND AUTOMATION LAB	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

The Robotics and Automation Laboratory introduce students to the fundamental principles and practical operation of modern robotic systems. Through simulations and hands-on experiments, students learn coordinate frames, transformations, kinematics, robotic arm operation, PLC-based control, ROS-based automation and control systems. The lab provides essential experience in programming, integrating, and controlling robots and automated systems used in advanced industrial environments.

Prerequisite

Basic knowledge of MATLAB or Python programming.

Course Outcomes

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

CO 1	Understand coordinate frames and transformations for robot manipulators through simulation and verification. (Cognitive Knowledge Level: Understand)
CO 2	Apply forward and inverse kinematics to analyse planar and spatial robots and validate the end-effector pose. (Cognitive Knowledge Level: Apply)
CO 3	Apply robot programming and control techniques to perform robotic operations and automation tasks. (Cognitive Knowledge Level: Apply)
CO 4	Develop and analyse PLC-based automation and control systems for industrial applications. (Cognitive Knowledge Level: Analyse)
CO 5	Implement and analyse advanced control strategies for robotic and automation systems. (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	3	2	3	3	-	-	2	2	1	2
CO 2	3	3	2	3	3	-	-	2	2	1	2
CO 3	3	3	2	3	3	-	-	2	2	1	2
CO 4	3	3	3	3	3	-	-	2	2	1	2
CO 5	3	3	3	3	3	-	-	2	2	1	2

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Evaluation
- Class work/ Assessment : 10 marks
- Viva (Self Study) : 10 marks

Viva voce / test : 15 marks
Record : 5 marks

End Semester Examination Pattern

Experiment part : 70 marks
Viva voce : 30 marks

Guidelines for award of marks for the experiment part:

Preliminary work : 15 Marks
Implementing the work/Conducting the experiment : 25 Marks
Performance, result and inference : 30 Marks

KNOWLEDGE IS POWER

SYLLABUS

LIST OF EXPERIMENTS

A minimum of **10** experiments is mandatory

1	FORWARD KINEMATICS ANALYSIS USING A FULL PARAMETER MODEL
1.1	Study and analysis of forward kinematics using a full parameter model of a manipulator.
1.2	Perform a study of coordinate frames and homogeneous transformations for robot manipulators and verify frame relationships through simulation.
1.3	Perform forward-kinematics simulation of a planar 2-DOF robot using the full parameter model and verify the end-effector pose experimentally on the physical arm.
1.4	Perform forward-kinematics simulation of a planar 3-DOF robot using the full parameter model and verify the end-effector pose experimentally on the physical arm.
1.5	Perform forward-kinematics simulation of a 6-DOF UR12e robot using the full parameter model and verify the end-effector pose experimentally on the physical arm.
2	FORWARD KINEMATICS ANALYSIS USING THE DENAVIT–HARTENBERG (DH) PARAMETER MODEL
2.1	Study and analysis of forward kinematics using a DH parameter model of a manipulator.
2.2	Perform forward-kinematics simulation of a planar 3-DOF robot using the DH parameter model and verify the end-effector pose experimentally on the physical arm.
2.3	Perform forward-kinematics simulation of a 6-DOF UR12e robot using the DH parameter model and verify the end-effector pose experimentally on the physical arm.
3	INDUSTRIAL AUTOMATION AND PLC PROGRAMMING
3.1	Study of PLC Programming.
3.2	Perform the development and implementation of a PLC-based automation system.
4	INTRODUCTION TO THE ROBOT OPERATING SYSTEM (ROS 2)
4.1	Perform a study of ROS 2 fundamentals, including its core components and tools.
4.2	Perform a vision-based robot pick-and-place operation using ROS 2.
5	UR12e ROBOT CONTROL AND AUTOMATION
5.1	Perform a study of UR12e robot programming, input/output control, and robot operations.
5.2	Perform a pick-and-place operation using a UR12e robot and conveyor system.
6	FUNDAMENTALS OF PID CONTROL SYSTEMS
6.1	Perform a study of PID Control Systems.

6.2	Perform PID control system design and tuning for dynamic systems.
7	INVERSE KINEMATICS AND CLOSED-LOOP PID CONTROL OF ROBOTIC SYSTEMS
7.1	Study and analyse the inverse kinematics of a robotic arm.
7.2	Perform inverse-kinematics simulation of a planar robot and verify the results on the physical arm.
7.3	Perform an inverse kinematics simulation of a spatial UR12e robot and compute all feasible joint solutions.
7.4	Perform PID control of a DC motor through simulation.
7.5	Perform the design and simulation of PID control for a robot arm.
8	ROBOTIC MANIPULATION AND WORKFLOW AUTOMATION
8.1	Perform the design, development, and implementation of a pick-and-place workflow.
8.2	Perform trajectory planning and path generation for a robot manipulator.
8.3	Perform IoT-based monitoring of a robotic automation cell.

Reference

1. Saha, S. K., *Introduction to Robotics*, McGraw-Hill Education, 2nd Edition, 2014.
2. Groover, M. P., Weiss, M., Nagel, R. N., Odrey, N. G., & Dutta, A. (2012). *Industrial Robotics: Technology, Programming, and Applications,* 2nd edition, Tata McGraw-Hill.
3. Craig, J. J., *Introduction to Robotics: Mechanics and Control*, Pearson Education, 4th Edition, 2017.

KNOWLEDGE IS POWER

B24ME3L07	THERMAL POWER LAB	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

The Thermal Power laboratory provides hands-on experience with internal combustion engines, compressors, and blowers. Students evaluate fuel and lubricant properties, engine performance, and cooling characteristics through experiments. It bridges theoretical concepts with real-world thermal system applications and develops essential analytical skills.

Prerequisite

Nil

Course Outcomes

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

CO 1	Explain the main parts and working of different internal combustion engines, blowers, and compressors. (Cognitive Knowledge Level: Understand)
CO 2	Experiment with important fuel and lubricant properties such as viscosity, flash point, and fire point using standard testing equipment. (Cognitive Knowledge Level: Apply)
CO 3	Make use of performance tests on various engines to calculate power, efficiency, and fuel consumption. (Cognitive Knowledge Level: Apply)
CO 4	Analyze cooling and combustion characteristics to find the best operating conditions for engines. (Cognitive Knowledge Level: Analyze)
CO 5	Analyze experimental data obtained from engines, blowers, and compressors by organizing and interpreting performance parameters. (Cognitive Knowledge Level: Analyze)

Mapping of Course Outcomes with Program Outcomes

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

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Evaluation
- Class work/ Assessment : 10 marks
- Viva (Self Study) : 10 marks

Viva voce / test : 15 marks
Record : 5 marks

End Semester Examination Pattern

Experiment part : 70 marks
Viva voce : 30 marks

Guidelines for award of marks for the experiment part:

Preliminary work : 15 Marks
Implementing the work/Conducting the experiment : 25 Marks
Performance, result and inference : 30 Marks

KNOWLEDGE IS POWER

SYLLABUS

LIST OF EXPERIMENTS

Minimum **12** experiments are mandatory (Including study)

1	Study of Internal Combustion engine and its components
2	Study on 2-Stroke and 4-Stroke Petrol and Diesel Engine by studying respective cut models
3	Performance test on Fiat Engine
4	Morse Test on Fiat Engine
5	Performance Evaluation of Volumetric Efficiency in a Kirloskar Diesel Engine
6	Determination of Optimum Cooling Water Temperature for Kirloskar Diesel Engine
7	Performance Test on Textool Four-Stroke Petrol Engine
8	Heat Balance Test on Textool Four-Stroke Petrol Engine
9	Determination of Frictional Power by Retardation Test on Ruston Engine
10	Study and Performance analysis on Blower
11	Study and Performance analysis on reciprocating compressor
12	Performance Test on Twin-Cylinder Kirloskar Four-Stroke Diesel Engine
13	Determination of Volumetric Efficiency of Textool Four-Stroke Petrol Engine
14	Performance Test on Ruston Four-Stroke Diesel Engine
15	Determination of Viscosity of Lubricating Oils and Fuels at Various Temperatures
16	Determination of Flash and Fire Points of Petroleum Fuels and Oils
17	Performance Analysis of Single-Cylinder Four-Stroke Multi-Fuel VCR Engine
18	Performance Evaluation of Computerized Two-Cylinder Four-Stroke Diesel Engine
19	Study of Dynamometers
20	Performance analysis of Four Cylinder High Speed Four stroke Petrol Engine.
21	Heat Balance Test on Four Cylinder High Speed Four stroke Petrol Engine.
22	Study and performance analysis of a steam power plant

Reference Books

1. Heywood, J. B., Internal Combustion Engine Fundamentals; McGraw-Hill, 2nd Edition, 2018.
2. Ganesan, V., Fundamentals of IC Engines; Tata McGraw-Hill, 4th Edition, 2012.
3. Turns, S. R., An Introduction to Combustion: Concepts and Applications; McGraw-Hill, 4th Edition, 2021.
4. Kirkpatrick, A. T. et al., Internal Combustion Engines: Applied Thermosciences; Wiley, 4th Edition, 2020.
5. Holman, J. P., Experimental Methods for Engineers; McGraw-Hill, 8th Edition, 2012.
6. Rajput, R. K., Thermal Engineering; Laxmi Publications, 10th Edition.

MAR ATHANASIUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution
Kothamangalam, Kerala, India

B.TECH MECHANICAL ENGINEERING

SEMESTER 5

(MINOR)

SYLLABUS

B24MEM51	DYNAMICS OF MACHINES	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 machinery dynamics, covering force analysis of machinery, balancing of rotating and reciprocating masses, gyroscopes, and energy fluctuations in machines. It also introduces the fundamentals of vibration, focusing on single degree of freedom systems, and enables students to analyze and design vibration systems with desired conditions, appreciating the physical significance of vibrations in real-world applications.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the principles of mechanism design and illustrate practical problem-solving approaches in mechanical systems. (Cognitive Knowledge Level: Understand)
CO 2	Apply the concepts of inertia force and inertia torque to analyze their effects on mechanisms. (Cognitive Knowledge Level: Apply)
CO 3	Explain and analyze the effects of unbalanced forces in rotating and reciprocating masses. (Cognitive Knowledge Level: Understand)
CO 4	Describe the effects of gyroscopic action in rotating systems and transportation vehicles. (Cognitive Knowledge Level: Understand)
CO 5	Explain the fundamental concepts of vibration and illustrate their relevance in the design of mechanisms. (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	1					1		
CO 2	3	2	1	1					1		
CO 3	3	3	1	2					1		
CO 4	3	3	2	1					1		
CO 5	3	2	1	2					1		

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	20	20
Understand	40	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Static and Dynamic Force Analysis of Mechanisms (8 hours)

Static force analysis- Analysis of four bar linkages and slider crank mechanism, equilibrium conditions, graphical method, Analysis of four bar and slider crank, mechanisms with sliding and pin friction.

Dynamic force analysis: Inertia force and inertia torque. D'Alemberts principle, analysis of mechanisms engine force analysis (reciprocating engines only)- piston side thrust-connecting rod force-piston effort (analytical method only).

MODULE 2: Balancing of Rotating and Reciprocating Masses (9 hours)

Balancing - static and dynamic balancing - balancing of masses rotating in one plane, balancing of masses rotating in several planes, dalby's method.

Balancing of reciprocating masses - balancing of multi-cylinder in line engines - V engines - balancing of machines.

MODULE 3: Gyroscopic Effects and Stability of Vehicles (9 hours)

Fundamentals of gyroscopes and gyroscopic couples.

Gyroscopic action on vehicles-two wheelers, four wheelers, Stability of an automobile – stability of a two-wheel vehicle, air planes and ships.–Stabilization of ship.

MODULE 4: Fundamentals of Mechanical Vibrations (9 hours)

Introduction to vibrations – free vibrations of single degree freedom systems – energy Method.

Undamped and damped free vibrations – viscous damping – critical damping - logarithmic decrement - Coulomb damping – harmonically excited vibrations.

Response of an undamped and damped system – beat phenomenon – transmissibility.

MODULE 5: Advanced Topics in Vibrations and Measurement (10 hours)

Whirling of shafts – critical speed - free torsional vibrations – self excitation and stability analysis - vibration control - vibration isolation – vibration absorbers.

Introduction to multi-degree freedom systems - vibration measurement - accelerometer – seismometer – vibration exciters.

Text Books

1. Ballaney P.L. Theory of Machines, Khanna Publishers.
2. S. S. Rattan, Theory of Machines, Tata McGraw Hill.
3. V. P. Singh, Theory of Machines, Dhanpat Rai.

References

1. E. Wilson, P. Sadler, Kinematics and Dynamics of Machinery, Pearson Education.
2. Ghosh, A. K. Malik, Theory of Mechanisms and Machines, Affiliated East West Press.
3. H. Myskza, Machines and Mechanisms Applied Kinematic Analysis, Pearson Education.

4. Holowenko, Dynamics of Machinery, John Wiley.
5. J. E. Shigley, J. J. Uicker, Theory of Machines and Mechanisms, McGraw Hill.
6. W.T. Thompson, Theory of vibration, Prentice Hall.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**8**
1.1	Static force analysis- Analysis of four bar linkages and slider crank mechanism, equilibrium conditions,	2
1.2	Analysis of four bar and slider crank, mechanisms with sliding and pin friction	2
1.3	Inertia force and inertia torque. D'Alemberts principle, analysis of mechanisms engine force analysis	2
1.4	piston side thrust-connecting rod force-piston effort	2
	Module 2	**9**
2.1	Balancing - static and dynamic balancing - balancing of masses rotating in one plane	2
2.2	balancing of masses rotating in several planes, dalby's method	3
2.3	Balancing of reciprocating masses - balancing of multi-cylinder in line engines	2
2.4	V engines - balancing of machines	2
	Module 3	**9**
3.1	Gyroscope – gyroscopic couples	2
3.2	Gyroscopic action on vehicles-two wheelers, four wheelers	2
3.3	Stability of an automobile – stability of a two-wheel vehicle	2
3.4	air planes and ships.–Stabilization of ship	3
	Module 4	**9**
4.1	Introduction to vibrations – free vibrations of single degree freedom systems – energy Method	2
4.2	Undamped and damped free vibrations – viscous damping – critical damping - logarithmic decrement - Coulomb damping –	3
4.3	harmonically excited vibrations	2
4.4	Response of an undamped and damped system – beat phenomenon – transmissibility	2
	Module 5	**10**
5.1	Whirling of shafts – critical speed - free torsional vibrations - vibration control - vibration isolation – vibration absorbers	2
5.2	self excitation and stability analysis	2
5.3	vibration control - vibration isolation – vibration absorbers	2
5.4	Introduction to multi-degree freedom systems -	2
5.5	vibration measurement - accelerometer – seismometer – vibration exciters	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. What are the conditions for static equilibrium of a body?
2. Explain inertia force and inertia torque.
3. Find the torque T and its direction of slider crank mechanism shown in the figure below to bring the system in equilibrium, given the forces acting on the slider, F = 5000N and a force of magnitude 1000N is applied on the connecting rod as shown in figure, the crank angle = 40^{o}. Length of the crank = 250mm, connecting rod = 750mm, AC =250mm.

Course Outcome 2 (CO2):

1. What are the conditions for static balancing and dynamic balancing?
2. There are four planes A, B, C and D. The masses attached and radius of

   rotation respectively are given as follows. m_1 = 20kg, m_2 = 30kg, m_3 = 24kg, m_4 = 26kg, r_1 = 9cm, r_2 = 7cm, r_3 = 10cm, r_4 = 12cm. The plane A is 12cm to the left of reference plane L. Planes B, C and D are 5cm, 30cm and 60cm respectively to the right of plane L. The distance between the reference planes L and M being 50cm. m2 is at an angle of 45^{O} from m1, m3 is at an angle of 75^{O} from m2 and m4 is at 135^{O} from m3. Find the magnitude and position of the balance mass required in planes L and M at a radius of 24 cm.
3. Explain the balancing of a four cylinder in-line engine

Course Outcome 3 (CO3):

1. Explain different planes of gyroscope.
2. What is the effect of gyroscope in the Stability of an automobile?
3. An aeroplane flying at 240 km/hr turns towards left and complete a quarter circle of 60 m radius. The mass of the rotary engine and the propeller of the plane amounts to 450 kg with a radius of gyration of 320 mm. the engine speed is 2000 rpm, clockwise when viewed from the rear. Determine the gyroscopic couple on the aircraft and state its effects. In what way is the effect changed when (i) the aeroplane turns towards right and (ii) the engine rotates clockwise when viewed from the front (nose end) and aeroplane turns (a) left (b) right?

Course Outcome 4 (CO4):

1. From fundamentals derive the expression for logarithmic decrement for a free damped longitudinal vibration system.

2. A machine of mass 75kg is mounted on springs and is fitted with a dashpot to damp out vibrations. There are three springs each of stiffness 10N/mm and it is found that the amplitude of vibration diminishes from 38.4 mm to 6.4 mm in two complete oscillations. Assuming that the damping force varies as the velocity, determine: 1. The resistance of the dashpot at unit velocity. 2. The ratio of the frequency of the damped vibration to the frequency of the undamped vibration. 3. The periodic time of the damped vibration.
3. Explain transmissibility in case of forced vibration.

Course Outcome 5 (CO5)

1. A shaft 1.5 m long, supported in flexible bearings at the ends carries two wheels each of 50 kg mass. One wheel is situated at the centre of the shaft and the other at a distance of 375 mm from the centre towards left. The shaft is hollow of external diameter 75 mm and internal diameter 40 mm. The density of the shaft material is 7700 kg/m3 and its modulus of elasticity is 200 GN/m2. Find the lowest whirling speed of the shaft, taking into account the mass of the shaft.
2. How the vibration of an automobile engine can be controlled?
3. What do you understand by vibration pickups? With neat diagram explain the working of a seismometer.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

FIFTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: **B24MEM51**

Course Name: **DYNAMICS OF MACHINES**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

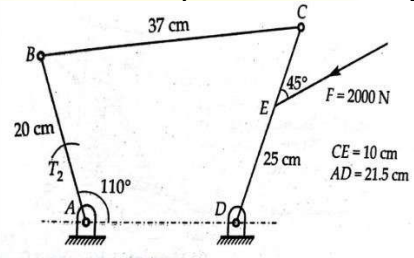
1 State principle of superposition.
2 What are the conditions for a body to be in equilibrium under the action of two forces, three forces and two forces and a torque?
3 When is a rotating system can be said to be dynamically balanced?.
4 Describe the working of a balancing machine.
5 What do you mean by spin, precession and gyroscopic plane?
6 How does gyroscope helps in the guidance of ships?
7 What is logarithmic decrement? Derive the relation for the same.
8 Define terms i) Magnification factor ii) Transmissibility
9 What do you mean by whirling of shafts?
10 Explain the principle of working of Accelerometer.

PART B

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

Module 1

11 In the figure given below. a four bar mechanism is shown. Find the torque T2 required and various forces for the equilibrium of the system.



(14 marks)

OR

12 A single cylinder vertical engine has a bore of 30cm and a stroke of 40 cm. The connecting rod is 100 cm long. The mass of the reciprocating parts is 140 kg. On expansion stroke with the crank at 30^0 from the top dead centre the gas pressure is 0.7 MPa. If the engine runs at 250 rpm, determine

i. Net force acting on piston
ii. Resultant load on gudgeon pin
iii. Thrust on the cylinder walls

(14 marks)

Module 2

13 Three masses m_1, m2, m3 with masses 10 kg, 9 kg, 16 kg respectively revolve in the same plane at radii 10cm, 12.5cm and 5cm respectively. The angular positions of m_2 and m_3 are 60^0 and 135^0 respectively from m_1. Determine the position and magnitude of mass m_4 at 15cm to balance the system.

(14 marks)

OR

14 The length of each connecting rod of 60^0 V-engine is 220mm and stroke is 100mm.The mass of the reciprocating parts is 1.2 kg per cylinder and the crank speed is 2400 rpm. Find the values of primary and secondary forces.

(14 marks)

Module 3

15 A ship is propelled by a turbine rotor having a mass of 6 tonnes and a speed of 2400 rpm. The direction of rotation of the rotor is hen viewed from the stren. The radius of gyration of the rotor is 450mm. Determine the gyroscopic effects when

i) Ship steers to the left in a curve of 60m radius at a speed of 18 knot (1knot = 1860 m/hr)

ii) Ship pitches 7.5 degrees above and 7.5 degrees below the normal position and the bow is descending with its maximum velocity, the pitching motion is simple harmonic motion with a time period of 18 seconds.

iii) Ship rolls and at the instant, its angular velocity is 0.035 rad/s counter clockwise when viewed from the stern.

(14 marks)

OR

16 A rear engine automobile is travelling along a track of 100 mm mean radius. Each 4 wheels have moment of inertia 2 kgm^2 and the effective diameter 60 cm. The rotating parts of engine have moment of inertia 1 kgm^2 . The engine axis is parallel to rear axle and crank shaft rotates in the same sense as the road wheels. The gear ratio between engine to back axle os 3:1. The vehicle weighs 1500 kg and has C.G 50 cm above road level. The width of track of vehicle is 1.5m. Determine the limiting speed of vehicle around the curve for all four wheels to maintain contact with the road surface if this is not cambered.

(14 marks)

Module 4

17 In a single –degree damped vibrating system a suspended mass of 8kg makes 30 oscillations in 18 seconds. The amplitude decreases to 0.25 of the initial value after 5 oscillations. Determine the

i) Stiffness of the spring
ii) Logarithmic decrement
iii) Damping factor
iv) Damping coefficient

(14 marks)

OR

18 The weight of an electric motor is 125N and runs at 1500 rpm.The armature weighs 35N and its centre of gravity lies 0.05cm from the axis of rotation. The motor is mounted on five springs of negligible damping so that the force transmitted is one –eleventh of the impressed force. Assume that the weight of the motor is equally distributed among the five springs. Determine

i. Stiffness of each spring
ii. Dynamic force transmitted to the base at operating speed
iii. Natural frequency of the system

(14 marks)

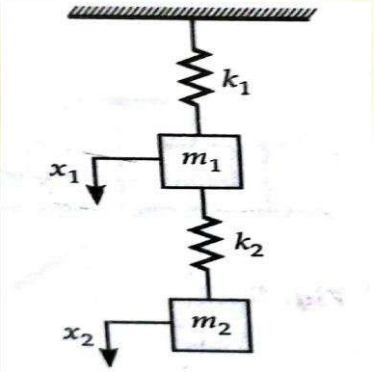
Module 5

19 A shaft 1.5 m long, supported in flexible bearings at the ends carries two wheels each of 50 kg mass. One wheel is situated at the centre of the shaft and the other at a distance of 375 mm from the centre towards left. The shaft is hollow of external diameter 75 mm and internal diameter 40 mm. The density of the shaft material is 7700 kg/m3 and its modulus of elasticity is 200 GN/m2. Find the lowest whirling speed of the shaft, taking into account the mass of the shaft.

(14 marks)

OR

20 Figure below. shows a vibrating system having two degrees of freedom. Determine the two natural frequencies of vibration and the ratio of amplitudes of the motion of m_1 and m_2 for the two modes of vibration. m_1=1.5 kg, m_2 =0.8 kg k_1=k_2=40 N/m



(14 marks)

B24MEM52	THERMAL SCIENCE AND ENGINEERING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

The course introduces the principles and applications of thermal energy conversion and utilization in major engineering systems. It covers steam power plants, gas turbines, internal combustion engines, and refrigeration and air-conditioning systems, which form the foundation of thermal energy technologies. Students will gain an understanding of energy transformation, cycle analysis, and performance evaluation of thermal systems. The course aims to build the knowledge required for efficient energy use and system analysis in thermal engineering applications.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand thermal energy conversion, energy transfer, and the performance characteristics of basic thermodynamic cycles. (Cognitive Knowledge Level: Understand)
CO 2	Understand the working, energy flow, and performance characteristics of major steam power plant components. (Cognitive Knowledge Level: Understand)
CO 3	Apply Brayton cycle concepts to evaluate gas turbine performance and explain the working principle of compressors and blowers. (Cognitive Knowledge Level: Apply)
CO 4	Apply performance-evaluation methods and engine performance equations to determine IC engine power, efficiencies, and fuel consumption for performance improvement. (Cognitive Knowledge Level: Apply)
CO 5	Understand refrigeration and air-conditioning systems and interpret psychrometric properties to select suitable processes for different applications (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			1					
CO 2	3	2	2			1					
CO 3	3	2	2	2	2	1					
CO 4	3	2	2	3	3	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	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Basics of Thermal energy (8 hours)

Forms of energy: thermal, mechanical, chemical, nuclear, and electrical. Heat and work: definitions, differences, and energy transfer mechanisms. First law of thermodynamics: energy conservation in closed and open systems. Ideal cycle - Carnot cycle, efficiency, real-world limitations. Basic working of Rankine cycle, components, layout, and energy flow through each stage. Methods to improve power plant efficiency such as reheating and regeneration (Description only).

MODULE 2: Steam Powerplants (9 hours)

Schematic diagram of steam power plants. Boilers - Cochran boiler, Babcock and Wilcox boiler, Benson boiler, boiler mountings and accessories. Steam Nozzle – principle, classification, nozzle efficiency. Steam turbines - working principle, classification. Condensers – jet and surface types. Cooling towers – natural and mechanical draft.

MODULE 3: Gas Turbines (9 hours)

Brayton cycle - components, layout, and energy flow through each stage (Simple Problems Only). Open and Closed cycle gas turbine. Methods to improve the performance – intercooling, reheating and regeneration. Air Compressors - Working principle, rotary and reciprocating compressors. Blowers – working principle.

MODULE 4: Testing of IC engines (9 hours)

Two-stroke and four-stroke engines. Performance Testing of I C Engines- Indicator diagram, mean effective pressure. Torque, Engine power- BHP, IHP. Engine efficiency, mechanical efficiency, volumetric efficiency, thermal efficiency, relative efficiency and Specific fuel consumption.

Rotary engines, Stratified charge engine, Super charging and turbo charging.

MODULE 5: Refrigeration and Airconditioning (10 hours)

Unit of Refrigeration, refrigeration effect, COP, difference between heat engine, heat pump and refrigerator. Ideal refrigeration cycle- Reversed Carnot cycle, Reversed Joule cycle. Vapour compression systems - simple cycle - representation on T- s and P- h Diagrams (Description only), Vapour absorption systems (Description only). Psychometric properties - revisiting basic concepts, psychometric chart. Psychometric processes - sensible heating and cooling, humidification and dehumidification.

Text Books

1. Nag, P. K., *Power Plant Engineering*, McGraw-Hill Education.
2. Cengel, Y. A. & Boles, M. A., *Thermodynamics: An Engineering Approach,* McGraw-Hill.
3. Ganesan, V., *Internal Combustion Engines*, McGraw-Hill Education.
4. Khurmi, R. S. & Gupta, J. K., *A Textbook of Refrigeration and Air Conditioning*, S. Chand Publishing.

Reference Books

1. Rajput, R. K., *Thermal Engineering*, Laxmi Publications.
2. Arora, S. C. & Domkundwar, S., *A Course in Power Plant Engineering*, Dhanpat Rai Publications.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**8**
1.1	Forms of energy: thermal, mechanical, chemical, nuclear, and electrical. Heat and work: definitions, differences, and energy transfer mechanisms. First law of thermodynamics: energy conservation in closed and open systems.	2
1.2	Ideal cycle - Carnot cycle, efficiency, real-world limitations.	2
1.3	Basic working of Rankine cycle, components, layout, and energy flow through each stage.	3
1.4	Methods to improve power plant efficiency such as reheating and regeneration (Description only).	1
	Module 2	**10**
2.1	Schematic diagram of steam power plants. Boilers - Cochran boiler, Babcock and Wilcox boiler, Benson boiler, boiler mountings and accessories.	3
2.2	Steam Nozzle – principle, classification, nozzle efficiency.	3
2.3	Steam turbines - working principle, classification.	2
2.4	Condensers – jet and surface types. Cooling towers – natural and mechanical draft.	2
	Module 3	**9**
3.1	Brayton cycle - components, layout, and energy flow through each stage (Simple Problems Only). Open and Closed cycle gas turbine.	4
3.2	Methods to improve the performance – intercooling, reheating and regeneration.	2
3.3	Air Compressors - Working principle, rotary and reciprocating compressors. Blowers – working principle.	3
	Module 4	**9**
4.1	Two-stroke and four-stroke engines.	1
4.2	Performance Testing of I C Engines- Indicator diagram, mean effective pressure. Torque, Engine power- BHP, IHP. Engine efficiency, mechanical efficiency, volumetric efficiency, thermal efficiency, relative efficiency and Specific fuel consumption.	4
4.3	Rotary engines, Stratified charge engine.	2
4.4	Super charging and turbo charging.	2
	Module 5	**9**
5.1	Unit of Refrigeration, refrigeration effect, COP, difference	2

	between heat engine, heat pump and refrigerator.	
5.2	Ideal refrigeration cycle- Reversed Carnot cycle, Reversed Joule cycle.	3
5.3	Vapour compression systems - simple cycle - representation on T-s and P- h Diagrams (Description only), Vapour absorption systems (Description only).	2
5.4	Psychometric properties - revisiting basic concepts, psychometric chart. Psychometric processes - sensible heating and cooling, humidification and dehumidification.	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. State and explain the First Law of Thermodynamics. Derive the energy equation for a closed system undergoing a cyclic process, clearly stating the assumptions.
2. A steam power plant has boiler and condenser pressures of 60 bar and 0.1 bar respectively. Steam coming out of the boiler is dry and saturated. The plant operates on the Rankine cycle. Calculate thermal efficiency.
3. Explain the concept of regeneration in steam power plants. With a neat sketch, describe the working principle and discuss how regeneration increases cycle efficiency.

Course Outcome 2 (CO2):

1. List and explain the essential boiler mountings and boiler accessories, highlighting the role of each in ensuring safe and efficient boiler operation.
2. Explain the working principle and classification of steam turbines. Distinguish between impulse and reaction turbines.
3. Describe the construction and working of jet and surface condensers with suitable diagrams.

Course Outcome 3 (CO3):

1. A gas turbine working on an air standard Brayton cycle operates between the temperature limits of 300 K and 1200 K and pressure limits of 101 kPa and 505 kPa. Calculate (a) thermal efficiency of the cycle, (b) compressor work in kJ/kg, (c) turbine work in kJ/kg, and (d) air flow rate for 2.0 kW of net power output.
2. Discuss the effect of intercooling, reheating, and regeneration on the performance of gas turbine power plants. Explain why these methods improve efficiency.
3. Explain the working principle of rotary compressors with neat diagrams. Describe any two types and comment on their applications and performance characteristics.

Course Outcome 4 (CO4):

1. With neat sketches, explain the working of two-stroke and four-stroke IC engines.

Compare them based on mechanical efficiency, power output, and applications.

2. A two-stroke diesel engine was motored when the meter reading was 1.5 kW. Then the test on the engine was carried out for one hour and the following observations were recorded: Brake torque = 120 Nm; Speed = 600 rpm; Fuel used = 2.5 kg; Calorific value of fuel = 40.3 MJ/kg; Cooling water used = 818 kg; Rise in temperature of cooling water = 10°C; Exhaust gas temperature = 345°C; Room temperature = 25°C; A:F = 32 : 1. Determine:
   a. Mechanical efficiency,
   b. Indicated thermal efficiency
3. Describe the construction and working of a rotary (Wankel) engine. Explain its advantages and limitations compared to a reciprocating IC engine.

Course Outcome 5 (CO5)

1. Draw the Reversed Joule (Bell–Coleman) cycle and explain all four processes.
2. Describe the vapour absorption refrigeration system (VARS) with a neat block diagram.
3. Discuss the psychrometric chart and its applications in air-conditioning system design. Explain how air properties are located and used in calculations

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

FIFTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: **B24MEM52**

Course Name: **THERMAL SCIENCE AND ENGINEERING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1		Define heat and work and explain any two key differences between them. Give one example each where energy is transferred as heat and as work.
2		List the various forms of energy in a thermodynamic system and explain each with one practical example
3		Explain why high-pressure boilers are preferred in modern steam power plants. Mention two advantages of Benson boilers over conventional boilers.
4		Explain the working principle of a steam turbine with a neat sketch.
5		Distinguish between open and closed cycle gas turbines.
6		Draw the T–S diagram of the Brayton cycle and label the four processes.
7		Explain the working principle of a two-stroke IC engine and mention one way it differs from a four-stroke engine.
8		Define brake power and indicated power. Explain how brake thermal efficiency of an IC engine is determined
9		Draw the T–s and P–h diagrams of a Vapour Compression Refrigeration cycle and briefly describe the four major processes shown.
10		Explain sensible heating and sensible cooling in an air-conditioning system.

PART B

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

Module 1

11	a.	State and explain the First Law of Thermodynamics. Derive the energy equation for a closed system undergoing a cyclic process, clearly stating the assumptions.	(6 marks)

b. A metallic A steam power plant works between pressures of 40 bar and 0.05 bar. If the steam supplied is dry saturated and the cycle of operation is Rankine cycle, find (a) Dryness fraction (b) Cycle efficiency. (8 marks)

OR

12 a. A heat engine receives 2,200 kJ/min of heat from a source at 500°C and rejects 1,200 kJ/min to a sink at 30°C. Determine the actual efficiency and compare it with the Carnot efficiency. (6 marks)

b. What is reheating in steam turbine power plants? Explain the process with a neat schematic and discuss how reheating helps improve power-plant efficiency. (8 marks)

Module 2

13 Steam enters a convergent-divergent nozzle at 2 MPa and 400°C with a negligible velocity and mass-flow rate of 2.5 kg/s and it exits at a pressure of 300 kPa. The flow is isentropic between the nozzle entrance and throat and overall nozzle efficiency is 93 per cent. Determine (a) throat, and (b) exit areas. (10 marks)

b. Classify steam nozzles and state the applications of each type. Draw their basic shapes (no need for detailed sketch). (4 marks)

OR

14 a. Explain the construction and working of a Cochran boiler with a neat sketch. (7 marks)

b. Explain the construction and working of natural draft and mechanical draft cooling towers with neat sketches. (7 marks)

Module 3

15 a. The pressure ratio and maximum temperature of a Brayton cycle are 5:1 and 923 K, respectively. Air enters the compressor at 1 bar and 298 K. Calculate for 1 kg of air flow, the compressor work, turbine work and the efficiency of the cycle. (9 marks)

b. Draw the Brayton cycle on P–V and T–S diagrams and explain each process. (5 marks)

OR

16 a. Explain the construction, working, and performance characteristics of reciprocating air compressors. (7 marks)

b. Describe the working principle of blowers and briefly highlight how they differ from compressors. (7 marks)

Module 4

17 The following observations were recorded during a trial of a 4-stroke single-cylinder diesel engine for a trial duration of 30 min. Fuel consumption is 4 Kg. The calorific value of fuel is 43 MJ/Kg, the average Indicator diagram is 8.5 cm^2, the length of the Indicator diagram is 8.5 cm, the spring constant is 5.5 bar/cm, the brake load is 150 Kg, the spring balance reading = 20 Kg, effective brake wheel diameter is 1.5 m, speed is 200 rpm, cylinder diameter is 30 cm, stroke is 45 cm. Calculate 1) Indicated power 2) Brake power 3) Mechanical efficiency 4) Indicated thermal efficiency, and 5) Heat carried by water if the jacket cooling water rate is

10 Kg/min and the temperature rise is 36 ºC. The specific heat capacity of water is 4.18 J/ KgºC. (14 marks)

OR

18 a. Explain the working of supercharging and turbocharging in IC engines. Discuss the advantages of each in improving power output and engine efficiency. (7 marks)

b. Describe the construction and working of a rotary (Wankel) engine. Explain its advantages and limitations compared to a reciprocating IC engine. (7 marks)

Module 5

19 a. Derive the expressions for the COP of a refrigerator, the COP of a heat pump, and the thermal efficiency of a heat engine, and establish the relationship between them. (6 marks)

b. Explain the following psychrometric processes with their representation on a psychrometric chart:
(a) Sensible heating
(b) Sensible cooling
(c) Humidification
(d) Dehumidification (8 marks)

OR

20 a. Explain the Reversed Carnot refrigeration cycle with neat sketches. Derive the expression for its COP and discuss why it is impractical for real systems. (7 marks)

b. With a neat schematic, explain the components and working of a complete air-conditioning system. Describe the function of each component. (7 marks)

B24MEM53	PRECISION MANUFACTURING AND MACHINING TECHNOLOGY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

Precision Manufacturing and Machining Technology introduces the fundamental concepts of metal cutting, machining processes, and surface generation required for producing accurate and high-quality components. The course familiarizes students with conventional machine tools, CNC systems, and non-traditional machining methods widely used in modern industries such as aerospace, automotive, electronics, and medical manufacturing. It bridges traditional machining principles with contemporary precision techniques, enabling learners from other disciplines to understand, analyze, and apply suitable manufacturing processes in multidisciplinary engineering applications.

Prerequisite

Nil

Course Outcomes

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

CO 1	Explain the fundamentals of machining processes, metal cutting principles, tool materials, and machinability aspects in precision engineering applications. (Cognitive Knowledge Level: Understand)
CO 2	Apply the working principles of lathe and drilling machines to select suitable operations, tooling, and calculate machining time for simple components. (Cognitive Knowledge Level: Apply)
CO 3	Apply milling and grinding principles to select appropriate machines, cutters, wheels, and evaluate material removal operations for precision surfaces. (Cognitive Knowledge Level: Apply)
CO 4	Demonstrate understanding of CNC turning and milling machines by identifying machine elements, coordinate systems, and writing simple G and M code programs. (Cognitive Knowledge Level: Apply)
CO 5	Explain and differentiate non-conventional machining processes based on working principles, process parameters, and suitable industrial applications. (Cognitive Knowledge Level: Appy)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	20	10	20
Understand	40	30	20
Apply	40	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 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) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

KNOWLEDGE IS POWER

SYLLABUS

MODULE 1: Fundamentals of Machining and Precision Engineering (8 hours)

Definition and scope of machining; evolution of precision manufacturing; role of machining in aerospace, automotive, electronics, medical, defense industries. Introduction to metal cutting; elements of cutting process; orthogonal and oblique cutting; rake, shear, clearance angles; chip formation mechanisms and chip types; chip breakers.

Machining parameters – cutting speed, feed, depth of cut, cutting fluids, tool geometry. Surface finish and accuracy; effect of machining parameters on surface integrity. Cutting tool materials – HSS, carbides, ceramics, CBN, PCD, coated tools; selection criteria; cutting fluids and selection. Machinability – factors; machinability index; tool wear – types.

MODULE 2: **Conventional Machine Tools and Machining Processes (9 hours)**

General purpose machine tools – lathe, drilling, milling, grinding. Lathe – working principles; constructional details. Lathe specification and classification; work-holding and tool-holding devices.

Lathe operations; machining time calculations. Drilling machines – specifications; types; work/tool holding devices. Twist drill geometry; drilling time calculation.

MODULE 3: CNC Machine Tools and Programming (9 hours)

Milling machines – Working principles and constructional details of column and knee type milling machine. Horizontal and Vertical milling machines – Types – Various accessories and work holding devices. Milling cutters and motions – Up and down milling – Types of milling cutters – Calculation of milling time.
Grinding machines – Surface, cylindrical, centerless and its types. Grinding wheels – Types – Abrasives, bonding, grain size – Dressing and truing – Selection of grinding wheels.

MODULE 4: CNC Machining Systems and Automation (8 hours)

Evolution of CNC and DNC systems; principle of operation; CNC structure and block diagram. Classification of CNC systems – open/closed loop; point-to-point and continuous path; absolute and incremental positioning. CNC lathe – configuration; tooling; work holding; coordinate systems; basic part programming (G/M codes). CNC milling – configuration; tooling; work holding; coordinate systems; basic part programming (G/M codes).

MODULE 5: Non-Traditional Machining Processes (9 hours)

Introduction to non-traditional machining; need and comparison with conventional machining. EDM-working principle; spark generation; process parameters; electrode materials; flushing; applications. Wire EDM – construction; working principle; applications. USM – principle; elements; material removal mechanism; uses. WJM and AWJM – mechanisms; equipment; parameters; applications. LBM and EBM – principles; working; advantages; precision applications.

Text Books

1. Serope Kalpakjian and Steven Schmid, *Manufacturing Engineering and Technology*, Pearson Education.
2. B. L. Juneja, G. S. Shekhon and N. Seth, *Fundamentals of Metal Cutting and Machine Tools*, New Age International.

3. Amitabha Ghosh and Ashok Kumar Mallik, *Manufacturing Science*, Affiliated East-West Press.
4. P. C. Sharma, *Production Technology*, S. Chand Publications.
5. R. K. Rajput, *Introduction to Basic Manufacturing Processes and Workshop Technology*, Laxmi Publications

Reference Books

1. M. C. Shaw, *Metal Cutting Principles*, Oxford University Press.
2. S. K. Radhakrishnan, P. K. Subramanyan and V. Raju, *CNC Machines*, New Age International.
3. Vijay K. Jain, *Advanced Machining Processes*, Allied Publishers.
4. G. F. Benedict, *Nontraditional Manufacturing Processes*, Marcel Dekker.
5. V. C. Venkatesh and Sudin G. Kapoor, *Precision Engineering*, Tata McGraw-Hill.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module1	**9**
1.1	Definition and scope of machining – Evolution of precision manufacturing – Role of machining in modern industries: aerospace, automotive, electronics, medical, defense.	1
1.2	Introduction to metal cutting – Elements of cutting process – Workpiece–tool interaction in orthogonal cutting and oblique cutting – Rake, shear and clearance angles – Chip formation mechanisms and types – Chip breaker	2
1.3	Machining parameters: Cutting speed, feed, depth of cut, cutting fluid and tool geometry	2
1.4	Surface finish and accuracy – Effect of machining parameters on surface integrity	1
1.5	Cutting tool materials: HSS, carbides, ceramics, CBN, PCD, coated tools – Selection criteria – Cutting fluids and their selection	2
1.6	Machinability – Factors affecting machinability – Machinability index – Tool wear – Types	1
	Module 2	**9**
2.1	General purpose machine tools – lathe, drilling, milling, shaping and grinding machines – Introduction	1
2.2	Lathe – Working principles and constructional details	2
2.3	Specification and classification of lathes – Work and tool holding devices	1
2.4	Specialized lathe operations – Machining time calculations	2
2.5	Drilling machines – Specifications and types – Work/tool holding devices	1
2.6	Twist drill geometry – Drilling time calculation	2

	Module 3	**9**
3.1	Milling machines – Working principles and constructional details of column and knee type milling machine	1
3.2	Horizontal and Vertical milling machines – Types – Various accessories and work holding devices	2
3.3	Milling cutters and motions – Up and down milling – Types of milling cutters – Calculation of milling time	2
3.4	Grinding machines – Surface, cylindrical, centerless and its types	2
3.5	Grinding wheels – Types – Abrasives, bonding, grain size – Dressing and truing – Selection of grinding wheels	2
	Module 4	**9**
4.1	Evolution of CNC and DNC systems – Principles of operation – Structure and block diagram of CNC machines	2
4.2	Classification of CNC systems – Open/Closed loop control – Point-to-point and continuous path – Absolute and incremental positioning	2
4.3	CNC Lathe – Machine configuration, tooling, work holding – Coordinate systems – Part programming basics (G and M codes)	2
4.4	CNC Milling – Machine configuration, tooling, work holding – Coordinate systems – Part programming basics (G and M codes)	3
	Module 5	**9**
5.1	Introduction – Need for non-traditional processes – Comparison with conventional machining	1
5.2	Electrical Discharge Machining (EDM) – Working principle – Spark generation mechanism – Electrode materials – Flushing – Applications	2
5.3	Wire EDM – Construction – Working principle – Applications	1
5.4	Ultrasonic Machining (USM) – Principle – Elements – Material removal mechanism – Uses	1
5.5	Water Jet Machining (WJM) and Abrasive Water Jet Machining (AWJM) – Mechanism – Equipment – Parameters – Applications	2
5.6	Laser Beam Machining (LBM) and Electron Beam Machining (EBM) – Principle – Working – Advantages – Precision applications	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Differentiate between orthogonal and oblique cutting with suitable examples.
2. Describe the geometry of a single-point cutting tool and explain its influence on chip formation.
3. Explain various types of chips formed during metal cutting and discuss the conditions under which each type is produced.
4. Compare different cutting tool materials (HSS, carbide, ceramics, CBN, PCD) based on properties and applications.
5. Discuss the factors affecting machinability and explain how machinability index is evaluated

Course Outcome 2 (CO2):

1. Explain the constructional features of an engine lathe and list the functions of its major components.
2. Differentiate between various lathe work-holding devices with suitable sketches.
3. Describe major lathe operations and outline the steps involved in calculating machining time.
4. Explain the geometry of a twist drill and discuss how each element influences drilling performance.
5. Compare different types of drilling machines and discuss their applications in manufacturing.

Course Outcome 3 (CO3):

1. Explain the construction and working of a column-and-knee type milling machine.
2. Differentiate between up-milling and down-milling with diagrams and examples.
3. Discuss the classification of milling cutters and explain their applications.
4. Describe different types of grinding machines and compare surface, cylindrical, and centreless grinding.
5. Explain the selection criteria for grinding wheels based on abrasive type, bond, and grain size.

Course Outcome 4 (CO4):

1. Explain the evolution of CNC systems and distinguish between CNC and DNC.
2. Differentiate between open-loop and closed-loop control systems used in CNC machines.
3. Describe absolute and incremental positioning with suitable part-programming examples.
4. Explain the basic structure of a CNC lathe and discuss the role of tooling and work-holding devices.
5. Write and explain a simple CNC program for a turning or milling operation using standard G and M codes.

Course Outcome 5 (CO5):

1. Explain the working principle of EDM and discuss the spark-generation mechanism.
2. Compare EDM and Wire EDM in terms of construction, process characteristics, and applications.
3. Describe the material removal mechanism in Ultrasonic Machining and list its industrial applications.
4. Differentiate between Water Jet Machining and Abrasive Water Jet Machining with examples.
5. Discuss the principle and precision applications of Laser Beam Machining and Electron Beam Machining.

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: **B24MEM53**

Course Name: **PRECISION MANUFACTURING AND MACHINING TECHNOLOGY**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define rake angle and explain its significance in metal cutting.
2. List any three factors affecting machinability. What are the advantages of the quick return mechanism in shaping machines?
3. State any three specifications of an engine lathe.
4. Write any three differences between drilling and reaming.
5. Distinguish between up-milling and down-milling.
6. State the functions of dressing and truing in grinding.
7. Differentiate between absolute and incremental positioning.
8. Write the functions of G00, G01, and M03 codes.
9. List any three advantages of EDM over conventional machining.
10. State the major components of an Ultrasonic Machining (USM) setup.

PART B

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

Module 1

11 a. Explain the elements of metal cutting with reference to shear plane, rake angle, and chip flow. (7 Marks)

b. Discuss the various types of chips formed during machining and the conditions that produce each type. (7 Marks)

OR

12 a. Explain the different cutting tool materials—HSS, carbide, ceramics, CBN, PCD—and compare their properties. (7 Marks)

b. Define machinability. Explain machinability index and the key factors influencing machinability. (7 Marks)

Module 2

13 a. With a neat sketch, describe the working principle and major parts of a centre lathe. (7 Marks)

b. Explain any four common lathe operations with neat sketches. (7 Marks)

OR

14 a. Explain the construction and working principle of a drilling machine. (7 Marks)

b. With a diagram, explain the geometry of a twist drill. Also write the formula for drilling time. (7 Marks)

Module 3

15 a. Explain various types of milling machines with neat sketch and state one application of each (7 marks)

b. Discuss different types of milling cutters and their applications. (7 Marks)

OR

16 a. Explain the working principle of surface and cylindrical grinding machines. (7 Marks)

b. Describe the important characteristics of grinding wheels—abrasive type, bond, grain size—and criteria for wheel selection. (7 Marks)

Module 4

17 a. Draw the block diagram of a CNC system and explain its major components. (7 Marks)

b. With suitable examples, explain G-codes and M-codes used in CNC part programming. (7 Marks)

OR

18 a. Differentiate between open-loop and closed-loop CNC systems with examples. (7 Marks)

b. Write a simple CNC turning program to face and turn a cylindrical component to a given diameter and length. (7 Marks)

Module 5

19 a. Explain the working principle of EDM with a neat sketch. Discuss the spark-generation mechanism. (7 Marks)

b. Compare Water Jet Machining (WJM) and Abrasive Water Jet Machining (AWJM) in terms of mechanism, parameters, and applications. (7 Marks)

OR

20 a. Describe the construction and working principle of Wire EDM. (7 Marks)

b. Discuss the principle, advantages, and applications of Laser Beam Machining and Electron Beam Machining. (7 Marks)

MAR ATHANASIUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution
Kothamangalam, Kerala, India

B.TECH MECHANICAL ENGINEERING

SEMESTER 5

(HONOURS)

SYLLABUS

B24MEH51	DESIGN FOR MANUFACTURING AND ASSEMBLY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course provides a comprehensive introduction to the principles of Design for Manufacture and Assembly (DFMA), highlighting its evolution, methodologies, and role in enhancing product design and production efficiency. The course addresses key manufacturing processes, material selection, and process capability analysis to support informed and cost-effective design decisions. Students gain insights into assembly processes, including design considerations for manual and automated assembly, as well as guidelines for product disassembly. In addition, the course examines design practices for various manufacturing operations such as machining, turning, milling, casting, moulding, and welding, with emphasis on material compatibility, process constraints, and design guidelines aimed at improving manufacturability, reducing costs, and enhancing overall product performance.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the design guidelines for manual assembly and their influence on efficient product assembly (Cognitive Level: Understand)
CO 2	Describe the general design principles for manufacturability and their role in improving production efficiency (Cognitive Level: Understand).
CO 3	Apply machinability principles to design and modify components for improved machining performance (Cognitive Level: Apply).
CO 4	Apply design principles to develop and refine components suitable for casting and injection moulding processes (Cognitive Level: Apply).
CO 5	Apply welding design guidelines to design and enhance components for reliable and efficient welded joints (Cognitive 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	1	1	1						1
CO 2	2	2	3		1	2				1	1
CO 3	2	3	3		2					1	1
CO 4	2	3	3		2					1	1
CO 5	2	2	3		2	2				1	1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	10	10
Understand	60	30	30
Apply		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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: DFMA Fundamentals and Manufacturing Processes (9 hours)

Introduction to DFMA: History of DFMA, Steps for applying DFMA, Advantages of applying DFMA, Reasons for not implementing DFMA. Introduction to Manufacturing Process: Classification of manufacturing processes, Basic manufacturing processes, Mechanical properties of materials, Introduction to materials and material selection, Classification of engineering materials, Material selection for product design, Process capability analysis.

MODULE 2: Design for Assembly and Disassembly (9 hours)

Introduction to Assembly: The assembly process, characteristics and applications, Economic significance of assembly, General taxonomies of assembly operation and systems, assembling a product. Design for Assembly: Introduction, Design consideration, DFA methodology, General Design Guidelines for Manual Assembly for Part Handling and for Insertion and Fastening, General Rules for Product Design for Automation, Design for Fasteners: Introduction, Design recommendation for fasteners. Design for disassembly.

MODULE 3: Design for Machining (9 hours)

Design for machining: Introduction to machining, Recommended materials for machinability, Machining Using Single-Point Cutting Tools, Machining Using Multipoint Tools. Design for tuning operation: Process description, typical characteristics and applications, Suitable materials, Design recommendations. Design for machining round holes: Introduction, Suitable materials, Design recommendations.

MODULE 4: Design for Milling and Casting (9 hours)

Design for milling: Process description, Characteristics and applications of parts produced on milling machines, Design recommendations. Sand casting: Introduction to sand casting, typical characteristics of sand cast part, Design recommendations. Die casting: Introduction, Applications, Suitable material consideration, Design recommendations.

MODULE 5: Design for Moulding and Welding (9 hours)

Injection moulding: Introduction, Typical characteristics of injection moulded parts, Effect of shrinkage, Suitable materials, Design recommendations.
Welding process: Different types of welding processes, Design recommendations.

Text Books

1. Geoffrey Boothroyd, Peter Dewhurst, Winston Knight, "Product Design for Manufacture and Assembly", CRC press, Third Edition.
2. A.K. Chitale and R.C. Gupta , "Product design and Manufacturing " - Prentice Hall of India, Fifth Edition.
3. Engineering Design- Dieter, George E., Linda C. Schmidt. , McGraw-Hill Education.
4. Molloy, O.; Tilley, S.; Warman, E.A., Design for Manufacturing and Assembly: Concepts, Architectures and Implementation,† Springer, Reprint.

Reference Books

1. James G. Bralla, "Design for Manufacturability Handbook", McGraw-Hill companies, New York, Second Edition.
2. Geoffrey Boothroyd, "Assembly Automation and Product Design", CRC press, 2nd Edn.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**8**
1.1	Introduction to DFMA: History of DFMA, Steps for applying DFMA, Advantages of applying DFMA,	2
1.2	Introduction to Manufacturing Process: Classification of manufacturing processes, Basic manufacturing processes	2
1.3	Mechanical properties of materials, Introduction to materials and material selection,	2
1.4	Classification of engineering materials, Material selection for product design, Process capability analysis.	2
	Module 2	**10**
2.1	Introduction to Assembly: The assembly process, Characteristics and applications, Economic significance of assembly	2
2.2	General taxonomies of assembly operation and systems, assembling a product	2
2.3	Design for Assembly: Introduction, Design consideration, DFA methodology, General Design Guidelines for Manual Assembly for Part Handling and for Insertion and Fastening	2
2.4	General Rules for Product Design for Automation, Design for Fasteners: Introduction	2
2.5	Design recommendation for fasteners. Design for disassembly	2
	Module 3	**10**
3.1	Design for machining: Introduction to machining	2
3.2	Recommended materials for machinability, Machining Using Single-Point Cutting Tools, Machining Using Multipoint Tools	2
3.3	Design for tuning operation: Process description, typical characteristics and applications, Suitable materials, Design recommendations	3
3.4	Design for machining round holes: Introduction, Suitable materials, Design recommendations.	3
	Module 4	**9**
4.1	Design for milling: Process description, Characteristics and applications of parts produced on milling machines, Design recommendations	3
4.2	Sand casting: Introduction to sand casting, typical characteristics of a sand cast part, Design recommendations	3
4.3	Die casting: Introduction, Applications, Suitable material consideration, Design recommendations.	3

	Module 5	**8**
5.1	Injection moulding: Introduction, Typical characteristics of injection moulded parts, Effect of shrinkage, Suitable materials, Design recommendations.	4
5.2	Welding process: Different types of welding processes, Design recommendations.	4
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Outline the four main steps for applying DFMA and state one primary advantage in terms of production efficiency.
2. Classify manufacturing processes into primary categories and provide one example of a basic process under each category.
3. Describe the classification of engineering materials.

Course Outcome 2 (CO2):

1. Describe the general taxonomies of assembly operations and systems.
2. Outline the DFA methodology steps and select two general design guidelines for insertion and fastening in manual assembly.
3. Discuss design recommendations for fasteners in the context of disassembly.

Course Outcome 3 (CO3):

1. Outline the process description, characteristics, applications, and design recommendations for turning operations.
2. Recommend materials for machinability, and discuss their impact on single-point and multipoint tool operations using examples
3. State two design recommendations for machining round holes to minimise tool wear and ensure accuracy.

Course Outcome 4 (CO4):

1. Describe the process and characteristics of milling and how it influences part design for applications like automotive components.
2. Outline design recommendations for parts produced on milling machines and sand-cast components
3. Critically analyse the applications, characteristics, and design guidelines for milling versus sand and die casting.

Course Outcome 5 (CO5)

1. Outline suitable materials and design recommendations for injection-moulded parts.
2. Propose design strategies for a hybrid component like an automotive dashboard, assessing trade-offs in cost, strength, and defect minimisation
3. Outline suitable materials and design recommendations for welded parts.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

FIFTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: **B24MEH51**

Course Name: **DESIGN FOR MANUFACTURING AND ASSEMBLY**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Outline the four main steps for applying DFMA and state one primary advantage in terms of production efficiency.

2 List three key mechanical properties of materials and explain how one of them affects material selection for a high-wear component like a cutting tool.

3 Explain the characteristics and applications of the assembly process, and state its economic significance in terms of labour costs.

4 Describe two key design considerations in DFA methodology, including one guideline for part handling in manual assembly.

5 List three recommended materials for good machinability and briefly explain why they are preferred in single-point cutting tool operations.

6 Describe the typical characteristics of a turning operation, including one application and one suitable material.

7 List three key characteristics of parts produced on milling machines and one typical application

8 Briefly describe the sand-casting process and state two design recommendations for draft angles.

9 List three typical characteristics of injection-moulded parts and one example of a suitable material.

10 Name two types of welding processes and provide one design recommendation for each.

PART B

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

Module 1

11 a. What are the advantages of applying DFMA during product design? (7 marks)

b. Explain the different selection processes for (i) primary process (ii) material (7 marks)

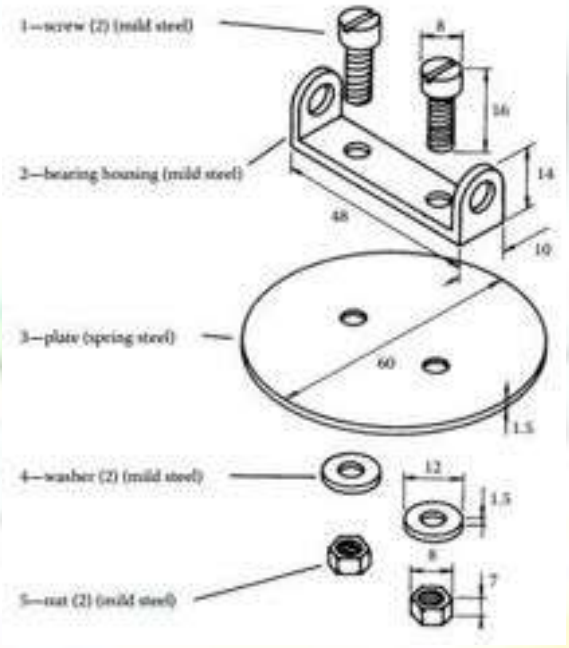
OR

12 a. Classify engineering materials into metals, polymers, and ceramics with one example each, and discuss how material selection affects assembly efficiency in DFMA. (7 marks)

b. Using a case of material selection for a pressure vessel, justify why steel might be preferred over aluminium, incorporating considerations from DFMA steps for manufacturability. (7 marks)

Module 2

13 Figure shows an exploded view of a diaphragm assembly from a gas flow meter. Determine a suitable assembly sequence for this product and carry out an analysis for manual assembly. Develop a redesign for this assembly with a reduced part count (14 marks)



OR

14 Explain in detail, general design guidelines for manual assembly, focusing on part handling, insertion and fastening. (14 marks)

Module 3

15 Detail the process description, typical characteristics, applications, and design recommendations for turning operations. (14 marks)

OR

16 a. For a steel shaft, suggest two materials with their machinability ratings and outline design adjustments to reduce cutting forces. (7 marks)

b. Provide three design recommendations to optimize tool life and surface quality for a

turned component like a pulley. (7 marks)

Module 4

17 Explain the sand-casting process, detailing typical characteristics of sand-cast parts and design recommendations. Design a sand cast bracket for a machinery frame, justifying material choices, pattern design, and gating system to minimise defects like porosity. (14 marks)

OR

18 a. Outline typical characteristics of sand cast parts and one application (7 marks)

b. Explain two design recommendations for fillets and ribs to improve strength, applying them to a cast engine mount with estimated weight reduction. (7 marks)

Module 5

19 For a medical device case, integrate welding for assembly, detailing types of welding processes and joint designs. (14 marks)

OR

20 a. Analyse different types of welding processes and their design recommendations (7 marks)

b. Explain the effect of shrinkage in injection moulding and its impact on part accuracy. (7 marks)

B24MEH52	MEASUREMENT METHODS FOR ENGINEERS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course provides a thorough understanding of the fundamental properties and behaviour of fluids that underpin the analysis and solution of engineering problems. Emphasis is placed on applying fluid mechanics principles to practical systems, including pipe flows, boundary layer phenomena, and fluid–solid interactions. The course also introduces essential analytical and experimental tools such as dimensional analysis for simplifying complex fluid flow problems and model testing for validating theoretical predictions in real-world engineering applications.

Prerequisites

Nil

Course Outcomes

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

CO 1	Identifying and quantifying systematic and random measurement errors and uncertainties in a measuring instrument. (Cognitive Knowledge Level: Apply)
CO 2	Select and justify the appropriate pressure sensing element for a given pressure range and application (Cognitive Knowledge Level: Apply)
CO 3	Understand the principles of operation for various thermal sensing elements for accurate temperature determination and calibration. (Cognitive Knowledge Level: Understand)
CO 4	Understand the operational methodologies of advanced techniques for complex flow and compositional analysis. (Cognitive Knowledge Level: Understand)
CO 5	Design and implement the fundamental architecture of a Data Acquisition (DAQ) system (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	1						1		
CO 2	3	2	1	1					1		
CO 3	3	3	1	2					1		
CO 4	3	3	2	1					1		
CO 5	3	2	1	2					1		

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	20	40	10
Understand	40	60	30
Apply	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Fundamentals of Measurement and Instrumentation (9 Hours)

Measurement characteristics, Measurement and Instrument Classifications. Characteristics of Instruments – Static and dynamic Measurements. Errors in Measurements, Systematic and Random errors, Uncertainty, Selection of measuring instruments. Reliability of Measuring instruments.

MODULE 2: Pressure Measurement and Calibration Techniques (9 Hours)

Measurement of Pressure, Various Pressure sensing elements. Bellows Inductance, Resistance types, Capacitive Pressure Transducers, Piezoelectric and Potentiometric Pressure Transducers, Strain gauge pressure sensors. Bridgeman Gauge for Very High-Pressure Measurement. Vacuum Measurement and McLeod gauge for very Low-Pressure Measurement. Pirani Gauge. Calibration Process, Dead weight Tester.

MODULE 3: Temperature Measurement and Calibration (9 Hours)

Measurement of Temperature, Thermometers, Thermometers Thermocouple. Resistance Temperature Detector (RTD), Thermistor, Bi-metallic Thermometers. Thermo-electric Pyrometers, Total radiation Pyrometers. Optical Pyrometers Pressure Thermometers, Infrared Thermometers, Temperature Calibration RTD and Thermocouple calibration.

MODULE 4: Advanced Measurement and Flow Diagnostics (9 Hours)

Advance Measurement Techniques- Shadowgraph, Schlieren imaging, Interferometer, Laser Doppler Anemometer, Particle Image Velocimetry Hot Wire Anemometer, Turbine Flow Meters, Telemetry, Orsat apparatus, 5 Gas Analysers, Smoke meters, Gas Chromatography.

MODULE 5: Digital Instrumentation and Data Acquisition Systems (9 Hours)

Microprocessors and Computers in measurement, Data logging and data acquisition (DAQ) system. Analog to Digital (A-D) and Digital to Analog Conversion (DAC). Pulse Code Modulation (PCM), 4-bit DAC convertor, R- 2R Ladder DAC.

Text Books

1. Holman, J.P., *Experimental methods for engineers*, McGraw-Hill.

Reference Books

1. Alan S Morris, Reza Langari, *Measurement and Instrumentation Theory and Application*, Academic Press, 3rd edn.
2. C.S Rangan, G.R Sarma, V S V Mani, *Instrumentation: Devices and Systems*, Tata McGraw-Hill, New Delhi, 2nd edn.
3. Doeblin, *Measurement System Application and Design*, McGraw-Hill, 4th edn.
4. Morris. A.S, *Principles of Measurements and Instrumentation*, Prentice Hall, 3rd edn.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**9**
1.1	Measurement characteristics, Measurement and Instrument Classifications	3
1.2	Characteristics of Instruments – Static and dynamic Measurements	2
1.3	Errors in Measurements, Systematic and Random errors, Uncertainty, Selection of measuring instruments	2
1.4	Reliability of Measuring instruments	2
	Module 2	**9**
2.1	Measurement of Pressure, Various Pressure sensing elements	2
2.2	Bellows Inductance, Resistance types, Capacitive Pressure Transducers, Piezoelectric and Potentiometric Pressure Transducers, Strain gauge pressure sensors.	3
2.3	Bridgeman Gauge for Very High-Pressure Measurement. Vacuum Measurement and McLeod gauge for very Low-Pressure Measurement	2
2.4	Pirani Gauge. Calibration Process, Dead weight Tester	2
	Module 3	**9**
3.1	Measurement of Temperature, Thermometers, Thermometers Thermocouple	3
3.2	Resistance Temperature Detector (RTD), Thermistor, Bi-metallic Thermometers. Thermo-electric Pyrometers, Total radiation Pyrometers	3
3.3	Optical Pyrometers Pressure Thermometers, Infrared Thermometers, Temperature Calibration RTD and Thermocouple calibration	3
	Module 4	**9**
4.1	Advance Measurement Techniques- Shadowgraph, Schlieren imaging	2
4.2	Interferometer, Laser Doppler Anemometer	2
4.3	Particle Image Velocimetry Hot Wire Anemometer, Turbine Flow Meters	2
4.4	Rotameters, Telemetry, Orsat apparatus, Gas Analysers, Smoke meters, Gas Chromatography	3
	Module 5	**9**
5.1	Microprocessors and Computers in measurement,	2
5.2	Data logging and data acquisition (DAQ) system	2
5.3	Analog to Digital (A-D) and Digital to Analog Conversion (DAC).	3
5.4	Pulse Code Modulation (PCM), 4-bit DAC convertor, R- 2R Ladder DAC.	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Distinguish between accuracy and precision with examples from engineering measurements.
2. Explain systematic and random errors. How can each be minimized in measurement systems?
3. Define Reliability of measuring instruments. What factors affect reliability in industrial applications?

Course Outcome 2 (CO2):

1. Compare inductive, resistive, and capacitive pressure transducers.
2. Explain the construction and working of a Bourdon tube with its advantages and limitations.
3. What is a strain gauge pressure sensor? Discuss its principle and write its applications.

Course Outcome 3 (CO3):

1. Explain the working principle of a thermocouple with reference to the Seebeck effect.
2. Differentiate between RTDs and Thermistors in terms of operating principle and characteristics.
3. Describe pyrometers and classify them. Where are they preferred over contact-type sensors?

Course Outcome 4 (CO4):

1. What is an LVDT? Explain its operation with a neat sketch.
2. Discuss the principle of a tachogenerator in velocity measurement.
3. Explain how piezoelectric elements are used for acceleration measurement.

Course Outcome 5 (CO5)

1. Draw the block diagram of a Data Acquisition System (DAQ) and explain each component.
2. What is A/D conversion? Explain the need for sampling and quantization.
3. Compare magnetic, optical and digital recording systems based on accuracy and response.

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: **B24MEH52**

Course Name: **MEASUREMENT METHODS FOR ENGINEERS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 What is measurement? Mention the uses of gauges, micrometers and dial gauge indicators in measurement system

2 Define systematic error and give one example.

3 Explain the working of Carbon pile pressure transducer

4 What is the purpose of a dead weight tester in pressure measurement?

5 Discuss the working of Pirani gauge with suitable sketches

6 Mention any two differences between RTD and Thermistor.

7 Discuss the principle of turbine flow meter

8 State one major application of Schlieren imaging.

9 Why are digital display units more preferred by researchers in measurement?

10 What is the function of an A/D converter?

PART B

Answer all questions. Each question carries 14 marks.

Module 1

11 Discuss the static and dynamic characteristics of measuring instruments with suitable examples. (14 marks)

OR

12 Explain in detail the different types of errors in measurement. How can systematic errors be minimized? (14 marks)

Module 2

13 Describe the working principles of capacitive, inductive, and piezoelectric pressure transducers. Compare their advantages and limitations. (14 marks)

OR

14 Explain high and low pressure measurement techniques using Bridgeman gauge, McLeod gauge, and Pirani gauge with diagrams. (14 marks)

Module 3

15 Explain the construction, principle, advantages, and limitations of RTDs and thermocouples. (14 marks)

OR

16 Discuss in detail radiation and optical pyrometers. How do they measure high temperatures without physical contact? (14 marks)

Module 4

17 With neat sketch explain Schlieren interferometer and shadowgraph. Mention its advantages and disadvantages. (14 marks)

OR

18 Explain the working of five gas analyzer and the working of a smoke meter. Mention its advantages and disadvantages. (14 marks)

Module 5

19 With neat diagrams, explain the working of R-2R Ladder DAC and Pulse Code Modulation (PCM). (14 marks)

OR

20 Explain the functional architecture of a data acquisition (DAQ) system. Describe how sensors, signal conditioning, and ADC/DAC play a role in measurement. (14 marks)

B24MEH53	ADVANCED MATERIAL PROCESSING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course provides a comprehensive understanding of modern manufacturing routes that enable precise control of material structure and performance. It guides students from fundamental concepts of material behaviour to specialized processing techniques employed in high-performance engineering applications. Emphasis is placed on the structure–processing–property relationship, integrating conventional and advanced methods such as advanced casting, metal forming, surface engineering, additive manufacturing, and severe plastic deformation. Through this integrated approach, students develop the knowledge required to select, design, and apply appropriate processing techniques for advanced alloys and functional materials, addressing application-specific requirements in sectors including aerospace, automotive, biomedical, solar energy, and smart material systems.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain and apply advanced casting and powder metallurgy techniques to control microstructure and material properties, including defect reduction in superalloys and titanium alloys. (Cognitive Level: Understand / Apply)
CO 2	Apply principles of stress–strain behaviour, forming mechanics, and severe plastic deformation to select suitable conventional and advanced metalworking processes for achieving desired material properties. (Cognitive Level: Apply)
CO 3	Explain and apply surface modification and coating techniques to improve performance, durability, and functional properties of engineering materials. (Cognitive Level: Understand / Apply)
CO 4	Differentiate and apply liquid- and solid-based additive manufacturing processes to fabricate components with suitable geometry and material performance. (Cognitive Level: Apply)
CO 5	Apply appropriate advanced processing techniques such as casting, powder metallurgy, severe plastic deformation, coatings, and additive manufacturing to address practical engineering applications in aerospace, automotive, biomaterials, solar, and smart material systems. (Cognitive Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Advanced Casting and Powder Metallurgy Processes (9 hours)

Introduction to advanced processing, Evolution from conventional methods, need for precision control over microstructure and properties, Structure–processing–property relationship.

Advanced casting techniques: Fundamental Principles of Liquid Metal Processing, Vacuum Induction Melting (VIM), Vacuum Arc Remelting (VAR), Electroslag Remelting (ESR), Vacuum Investment Casting (VIC), Directional Solidification (DS) Casting, Squeeze Casting, Vacuum Precision Die Casting, Continuous Casting of Superalloy Rods.

Powder Metallurgy (PM): Powder production methods, compaction, sintering processes - Hot Isostatic Pressing (HIP), Spark Plasma Sintering (SPS), Vacuum Sintering, densification mechanisms, defect elimination in advanced alloys like titanium and superalloys.

MODULE 2: Advanced Metal Forming and Severe Plastic Deformation (10 hours)

Introduction and classification of metalworking processes, Effect of properties on forming and formability, Behaviour of materials, Concept of stress and strain, Hydrostatic and deviatoric stresses, Flow curve, Yield criteria for ductile materials, plastic stress-strain relationships, Yielding and ductility during instability, Effect of strain rate and temperature on flow properties, Mechanics of metalworking, Hot and cold working.

Forming: Forging, rolling, extrusion, drawing principles and defects (with problems).

Sheet metal forming: Deep drawing, bending, stretch forming techniques (with problems).

Advanced forming: Superplastic forming, hydroforming, incremental sheet forming, micro/nano-forming, high-energy-rate forming.

Severe Plastic Deformation (SPD): Equal Channel Angular Pressing (ECAP), High-Pressure Torsion (HPT) for ultrafine-grained (UFG) materials.

MODULE 3: Surface Engineering and Coating Technologies (8 hours)

Coating and Surface Engineering**.** Need for surface modification and preparation: Cleaning, grit blasting, and activation methods. Coating techniques: PVD, CVD, thermal spraying (Plasma, HVOF, flame, Cold), electroplating, electroless plating, diffusion coatings (carburizing, nitriding, aluminizing), laser surface modification, Nanostructured coatings.

MODULE 4: Additive Manufacturing Technologies (8 hours)

Introduction to Additive Manufacturing, Liquid Additive Manufacturing - Molten Form Processes, Polymerizable Form Processes, Solid Additive Manufacturing -Powder-Based Processes, Laminar-Based Processes.

MODULE 5: Advanced Manufacturing Applications in Engineering Systems (10 hours)

Aerospace: Vacuum Arc Remelting (VAR) for Turbine-Engine Superalloys, Thermal Barrier Coatings (TBC) via Plasma Spraying, Laser Powder Bed Fusion (LPBF) for Topology-Optimized Brackets.

Automobile: Squeeze Casting of Al–Si–Mg Lightweight Wheels, DLC (Diamond-Like Carbon) Coatings for Engine Components.

Biomaterial: Powder Metallurgy (PM) + HIP for Ti-6Al-4V Implants, TiN Coating via CVD

for Dental Implants.

Solar Cells: Directionally Solidified (DS) Silicon Ingots, 3D Printed Electrodes for Perovskite Modules.

Smart Material: Spark Plasma Sintering (SPS) of NiTi Shape Memory Alloys, ECAP Processing of Mg Alloy for Biomedical Implants, Laser Surface Hardening of NiTi Actuators.

Text Books

1. William D. Callister and David G. Rethwisch, *Materials Science and Engineering: An Introduction*, Wiley, 10th ed.
2. William F. Hosford and Robert M. Caddell, *Metal Forming: Mechanics and Metallurgy*, Cambridge University Press 4th ed.
3. S. Kalpakjian and S. Schmid, *Manufacturing Engineering and Technology*, Pearson, 7th ed.
4. J. R. Davis, *Surface Engineering for Corrosion and Wear Resistance*, ASM International, 2001.
5. Ian Gibson, David W. Rosen, and Brent Stucker, *Additive Manufacturing Technologies*, Springer, 3rd ed., 2021.

Reference Books

1. R. Subramanian, Advanced Materials Processing and Manufacturing, CRC Press, 2018.
2. M. F. Ashby, *Materials Selection in Mechanical Design*, Butterworth-Heinemann, 5th ed.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**9**
1.1	Introduction to advanced processing, Evolution from conventional methods, need for precision control over microstructure and properties, Structure–processing–property relationship.	2
1.2	Advanced casting techniques: Fundamental Principles of Liquid Metal Processing, Vacuum Induction Melting (VIM), Vacuum Arc Remelting (VAR), Electroslag Remelting (ESR), Vacuum Investment Casting (VIC), Directional Solidification (DS) Casting, Squeeze Casting, Vacuum Precision Die Casting, Continuous Casting of Superalloy Rods.	4
1.3	Powder Metallurgy (PM): Powder production methods, compaction, sintering processes - Hot Isostatic Pressing (HIP), Spark Plasma Sintering (SPS), Vacuum Sintering, densification mechanisms, defect elimination in advanced alloys like titanium and superalloys.	3

	Module 2	**10**
2.1	Introduction and classification of metalworking processes, Effect of properties on forming and formability, Behaviour of materials, Concept of stress and strain, Hydrostatic and deviatoric stresses, Flow curve, Yield criteria for ductile materials, plastic stress-strain relationships, Yielding and ductility during instability, Effect of strain rate and temperature on flow properties, Mechanics of metalworking, Hot and cold working.	3
2.2	Forming: Forging, rolling, extrusion, drawing principles and defects (with problems)	2
2.3	Sheet metal forming: Deep drawing, bending, stretch forming techniques (with problems)	2
2.4	Advanced forming: Superplastic forming, hydroforming, incremental sheet forming, micro/nano-forming, high-energy-rate forming.	2
2.5	Severe Plastic Deformation (SPD): Equal Channel Angular Pressing (ECAP), High-Pressure Torsion (HPT) for ultrafine-grained (UFG) materials.	1
	Module 3	**8**
3.1	Coating and Surface Engineering**.** Need for surface modification and preparation: Cleaning, grit blasting, and activation methods.	2
3.2	Coating techniques: PVD, CVD, thermal spraying (Plasma, HVOF, flame, Cold), electroplating, electroless plating	3
3.3	diffusion coatings (carburizing, nitriding, aluminizing), laser surface modification, Nanostructured coatings.	3
	Module 4	**8**
4.1	Introduction to Additive Manufacturing	2
4.2	Liquid Additive Manufacturing - Molten Form Processes, Polymerizable Form Processes	3
4.3	Solid Additive Manufacturing -Powder-Based Processes, Laminar-Based Processes.	3
	Module 5	**10**
5.1	Aerospace: Vacuum Arc Remelting (VAR) for Turbine-Engine Superalloys, Thermal Barrier Coatings (TBC) via Plasma Spraying, Thermal Barrier Coatings (TBC) via Plasma Spraying, Laser Powder Bed Fusion (LPBF) for Topology-Optimized Brackets.	2
5.2	Automobile: Squeeze Casting of Al–Si–Mg Lightweight Wheels, DLC (Diamond-Like Carbon) Coatings for Engine Components	2
5.3	Biomaterial: Powder Metallurgy (PM) + HIP for Ti-6Al-4V Implants, TiN Coating via CVD for Dental Implants	2
5.4	Solar Cells: Directionally Solidified (DS) Silicon Ingots, 3D Printed Electrodes for Perovskite Modules	2
5.5	Smart Material: Spark Plasma Sintering (SPS) of NiTi Shape Memory Alloys, ECAP Processing of Mg Alloy for Biomedical Implants, Laser Surface Hardening of NiTi Actuators.	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the evolution of advanced materials processing and the structure–processing–property relationship.
2. Describe principles of advanced casting techniques (VIM, VAR, ESR, VIC, DS, Squeeze Casting, Vacuum Precision Die Casting).
3. Understand powder metallurgy processes including compaction, sintering (HIP, SPS, Vacuum), and defect elimination in advanced alloys.
4. Analyze process parameters to optimize casting and powder metallurgy operations.
5. Evaluate microstructure and densification in advanced alloys through case studies or laboratory simulations.
6. Appreciate the role of precision processing in improving material performance and industrial applications.

Course Outcome 2 (CO2):

1. Explain material behavior under stress and strain, including hydrostatic/deviatoric stresses and flow curves.
2. Compare hot and cold working processes, sheet metal forming, and advanced forming techniques.
3. Understand Severe Plastic Deformation (ECAP, HPT) for ultrafine-grained materials.
4. Solve problems related to forming processes, material flow, and defect prediction.
5. Demonstrate selection of appropriate forming technique for specific industrial applications.
6. Develop an appreciation for advanced forming methods to achieve superior mechanical properties.

Course Outcome 3 (CO3):

1. Explain the necessity of surface modification and preparation techniques.
2. Classify coating processes: PVD, CVD, thermal spraying, electroplating, diffusion coatings, and laser surface modification.
3. Analyze surface treatment techniques for specific applications.
4. Evaluate coating quality and performance through laboratory or simulation data.
5. Recognize the importance of surface engineering in enhancing durability and functional properties of materials.

Course Outcome 4 (CO4):

1. Understand the principles of additive manufacturing and classify processes: liquid-based, powder-based, and laminar-based.
2. Explain the material-process relationship for complex geometries.
3. Select appropriate additive manufacturing process based on material and application requirements.
4. Simulate or design simple AM components using industry-standard parameters.

5. Appreciate AM as a transformative technology for precision engineering and customized manufacturing.

Course Outcome 5 (CO5)

1. Identify advanced processing techniques in aerospace, automotive, biomaterials, solar cells, and smart materials.
2. Explain the application of VAR, LPBF, TBC, DLC coatings, PM+HIP, SPS, ECAP, and laser surface hardening in industrial contexts.
3. Analyze case studies to evaluate process selection and optimization for high-performance applications.
4. Correlate material properties with processing techniques for targeted industrial needs.
5. Appreciate the societal and industrial impact of advanced materials processing in emerging technologies.

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: **B24MEH53**

Course Name: **ADVANCED MATERIAL PROCESSING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the structure–processing–property relationship in materials.
2. List any four advanced casting techniques and mention one application of each.
3. Define flow curve and explain its significance in metal forming.
4. Distinguish between hot working and cold working of metals.
5. What is the purpose of grit blasting in surface preparation?
6. Differentiate between PVD and CVD coating techniques.
7. Name two liquid-based and two powder-based additive manufacturing processes.
8. State two advantages of additive manufacturing over conventional manufacturing.
9. Mention one application of Thermal Barrier Coatings (TBC) in aerospace.
10. Explain the use of HIP in biomedical implants.

PART B

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

Module 1

11. Explain the working principle, process steps, and industrial applications of Vacuum Arc Remelting (VAR). Include a labeled schematic diagram. (14 marks)

OR

12. Describe Powder Metallurgy processes, highlighting compaction, sintering, and densification mechanisms. Discuss their application in titanium and superalloys. (14 marks)

Module 2

13. Explain the principles of forging, rolling, and extrusion. Discuss typical defects in each process and methods to minimize them. (14 marks)

OR

14. Describe Severe Plastic Deformation techniques such as ECAP and HPT. Explain how these processes produce ultrafine-grained materials. (14 marks)

Module 3

15. Compare thermal spraying, electroplating, and laser surface modification techniques in terms of process, applications, and limitations. (14 marks)

OR

16. Explain diffusion coatings such as carburizing and nitriding. How do these processes enhance surface properties of engineering components? (14 marks)

Module 4

17. Explain Liquid Additive Manufacturing processes (molten form and polymerizable form). Discuss the advantages and industrial applications of each. (14 marks)

OR

18. Discuss Solid Additive Manufacturing (powder-based and laminar-based processes) and highlight key challenges in achieving dimensional accuracy and material properties. (14 marks)

Module 5

19. Discuss the application of advanced processing techniques in aerospace (VAR, LPBF, TBC). Include at least one case study or example. (14 marks)

OR

20. Explain the use of advanced processing in automotive, biomedical, and solar cell applications, highlighting at least one technique for each sector. (14 marks)

MAR ATHANASIUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution
Kothamangalam, Kerala, India

B.TECH MECHANICAL ENGINEERING

SEMESTER 6

SYLLABUS

SEMESTER 6

SLOT	COURSE NO.	COURSES	L-T-P-S	HOURS	CREDIT
A	B24ME3T06	DESIGN OF MACHINE ELEMENTS	3-1-0-5	4	4
B	B24ME3T07	HEAT AND MASS TRANSFER	3-1-0-5	4	4
C	B24ME3T08	FINITE ELEMENT METHODS	3-1-0-5	4	4
D	B24ME3T09	ADVANCED AUTOMOTIVE SYSTEMS	3-1-0-5	4	4
E	B24ME3P2x	PROGRAMME ELECTIVE II	2-1-0-4	3	3
F	B24ME3G1x	OPEN ELECTIVE I	2-1-0-4	3	3
G	B24ME3L08	THERMAL SYSTEMS LAB	0-0-3-2	3	2
H	B24ME3L09	COMPUTER AIDED DESIGN AND ANALYSIS LAB	0-0-3-2	3	2
M	B24MEM6x	MINOR	3-1-0-5	4	4
N	B24MEH6x	HONOURS	3-1-0-5	4	4
			TOTAL*	**36**	**26**

PROGRAMME ELECTIVE II

B24ME3P21	MAINTENANCE MANAGEMENT AND RELIABILITY ENGINEERING
B24ME3P22	FINANCIAL ENGINEERING
B24ME3P23	TECHNOLOGY MANAGEMENT
B24ME3P24	INDUSTRY 4.0 AND INTERNET OF THINGS
B24ME3P25	DATA STRUCTURES AND ALGORITHMS
B24ME3P26	SYSTEM MODELING AND SIMULATION
B24ME3P27	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING
B24ME3P28	ALGORITHMS FOR NON TRADITIONAL OPTIMIZATION

OPEN ELECTIVE I

B24ME3G11	QUANTITATIVE TECHNIQUES FOR ENGINEERS
B24ME3G12	INTRODUCTION TO PRODUCT DEVELOPMENT
B24ME3G13	OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT
B24ME3G14	AUTOMOTIVE TECHNOLOGY
B24ME3G15	NON DESTRUCTIVE TESTING
B24ME3G16	MATERIAL HANDLING SYSTEMS
B24ME3G17	FUNDAMENTALS OF DATA ANALYSIS

B24ME3T06	DESIGN OF MACHINE ELEMENTS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course introduces the fundamental principles and methodologies for the analysis and design of machine elements. It covers the design of shafts, belt drives, bearings, and gear systems, including spur, helical, bevel, and worm gears, with emphasis on selection criteria, strength, rigidity, and performance considerations. The course equips students with the knowledge required to analyze and design standard machine components for effective mechanical system development.

Prerequisites

Nil

Course Outcomes

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

CO 1	Apply strength and rigidity criteria to design shafts subjected to static and fatigue loading conditions. (Cognitive Knowledge Level: Apply)
CO 2	Apply standard bearing design principles to determine the suitability and dimensions of journal, ball, and roller bearings. (Cognitive Knowledge Level: Apply)
CO 3	Apply standard design procedures to select flat belt and V-belt drive systems, ensuring safe and efficient power transmission. (Cognitive Knowledge Level: Apply)
CO 4	Apply gear design principles to design spur and helical gear systems for given operating requirements. (Cognitive Knowledge Level: Apply)
CO 5	Apply standard design methodologies to design bevel gear and worm gear systems for specified service conditions. (Cognitive Knowledge Level: Apply)

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	10	10	10
Understand	30	30	30
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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Shafts and Couplings (12 hours)

Design of Shafts hollow shafts based on Bending Moment, Twisting Moment, Combined Bending & Twisting Moments, Axial Loads in Addition to Combined Torsional and Bending Loads, Rigidity and Stiffness.

Design of Coupling- selection, classification, rigid and flexible coupling, design of keys and pins.

MODULE 2: Bearing Design (9 hours)

Sliding contact bearing: - lubrication, lubricants, viscosity, journal bearings, hydrodynamic theory, Petroff's equation, bearing characteristic number, Sommerfeld number, Heat generated in bearings, Heat dissipated by bearings, Design procedure of Journal bearings.

Ball and roller bearings: - Types, bearing life, static and dynamic load capacity, Stribeck's Equation, selection of bearings.

MODULE 3: Belt Drive Design (7 hours)

Flat belt: Types of belt drives, material for belts, causes of slip, creep in belts, analysis of open and crossed belt drives, belt tension analysis, centrifugal tension, Power transmitted by flat belts, pulleys for flat belts, Design procedure of flat belts.

V-belt: Advantages and limitations, selection, power rating, pulleys, Design procedure of V-belts.

MODULE 4: Spur and Helical Gears (10 hours)

Materials of gears, terminology of spur Gear, Interference and undercutting, Gear tooth failures, Beam strength of Gear tooth, Estimation of module, Buckingham's equation for dynamic load, wear load, endurance strength of tooth, Gear proportions, Merits and demerits of each type of gears, Design procedure of Spur gear.

Helical gears: - Terminology, Virtual or equivalent number of teeth, Tooth proportions, Beam strength, and Wear strength of Helical gears, Design procedure of Helical gear.

MODULE 5: Bevel and Worm Gears (7 hours)

Bevel gears: - Classification, Terminology, Pitch angle for bevel gears, Strength of bevel gear, beam strength, wear tooth load, Formative number of teeth, Design procedure of Bevel gear.

Worm gears: - Characteristics of worm gears, Terminology, Advantages and disadvantages, Applications, Terms in Worm gear, Strength of Worm gear, Dynamic strength, Wear tooth load, Design procedure of Worm gear.

Design Data Books (permitted for reference in the university examination)

1. Mahadevan K. and K. Balaveera Reddy, *Design Data Handbook, Mechanical Engineers in SI and Metric Units*, CBS Publishers & Distributors.
2. K. Lingaiah, *Machine Design Data Book*, 2nd ed., McGraw Hill Education.
3. *PSG Design Data - Data Book of Engineers*, Kalaikathir Achhangham.

Text Books

1. K. Raghavendra, *Design of Machine Elements I & II*, CBS Publishers & Distributers.
2. V. B. Bhandari, *Design of Machine Elements,* McGraw-Hill Education.

Reference Books

1. Richard G. Budynas and J. Keith Nisbett, *Shigley's Mechanical Engineering Design*, McGraw- Hill Education.
2. S. Md. Jalaludeen, *Machine Design Vol. I&II*, Anuradha Publications.
3. M. F. Spotts, T. E. Shoup, *Design of Machine Elements*, Pearson Education.
4. Robert L. Norton, *Machine Design,* 5th ed., Pearson Education.
5. Robert L. Mott, *Machine Elements in Mechanical Design,* Pearson Education.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**12**
1.1	Design of Shafts hollow shafts based on Bending Moment, Twisting Moment, Combined Bending & Twisting Moments, Axial Loads in Addition to Combined Torsional and Bending Loads, Rigidity and Stiffness.	8
1.2	Design of Coupling- selection, classification, rigid and flexible coupling, design of keys and pins	4
	Module 2	**9**
2.1	Sliding contact bearing: - lubrication, lubricants, viscosity, journal bearings, hydrodynamic theory, Petroff's equation, bearing characteristic number, Sommerfeld number, Heat generated in bearings, Heat dissipated by bearings, Design procedure of Journal bearings.	5
2.2	Ball and roller bearings: - Types, bearing life, static and dynamic load capacity, Stribeck's Equation, selection of bearings.	4

	Module 3	**7**
3.1	Flat belt: Types of belt drives, material for belts, causes of slip, creep in belts, analysis of open and crossed belt drives, belt tension analysis, centrifugal tension, Power transmitted by flat belts, pulleys for flat belts, Design procedure of flat belts.	4
3.2	V-belt: Advantages and limitations, selection, power rating, pulleys, Design procedure of V- belts.	3
	Module 4	**10**
4.1	Materials of gears, terminology of spur Gear, Interference and undercutting, Gear tooth failures, Beam strength of Gear tooth, Estimation of module, Buckingham's equation for dynamic load, wear load, endurance strength of tooth, Gear proportions, Merits and demerits of each type of gears, Design procedure of Spur gear.	6
4.2	Helical gears: - Terminology, Virtual or equivalent number of teeth, Tooth proportions, Beam strength, and Wear strength of Helical gears, Design procedure of Helical gear.	4
	Module 5	**7**
5.1	Bevel gears: - Classification, Terminology, Pitch angle for bevel gears, Strength of bevel gear, beam strength, wear tooth load, Formative number of teeth, Design procedure of Bevel gear.	4
5.2	Worm gears: - Characteristics of worm gears, Terminology, Advantages and disadvantages, Applications, Terms in Worm gear, Strength of Worm gear, Dynamic strength, Wear tooth load, Design procedure of Worm gear.	3
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain rigidity-based shaft design with one good example.

2. A power transmission shaft is supported in bearings 2 m apart and carries a pulley weighing 1 kN at its midpoint and it receives power by a belt drive under mild shock operating conditions. The shaft transmits power to another machine by means of a flexible coupling just outside the right bearing. The power transmitted is 20 kW at 110 rpm. The ratio of belt tensions is 3:1and the maximum belt tension is limited to 2.5 kN. Estimate the size of the shaft if the permissible stress in shear is 50 MPa. Also, calculate the twist in the shaft if the modulus of rigidity is 80 GPa.

3. Design a muff coupling to connect two steel shafts transmitting 25 kW of power at 360 rpm. Shafts and key are made up of Plain carbon steel 30C8 (S_{yt} = S_{yc} = 400 N/mm²). The sleeve is made of FG 200 grey cast iron (S_{ut} = 200 N/mm²). The shafts and key have a safety factor of 4. Based on ultimate strength, the sleeve has a factor of safety of 6.

Course Outcome 2 (CO2):

1. Distinguish between hydrostatic and hydrodynamic bearings.
2. A single row deep groove ball bearing has a dynamic load capacity of 40500 N and operates on the following work cycle.
    a. Radial load of 5000N at 500 rpm for 25% of the time
    b. Radial load of 10000N at 700 rpm for 50% of the time
    c. Radial load of 7000N at 400rpm for the remaining 25% of the time.
    d. Calculate expected life of bearing in hours.
3. Design a full journal bearing subjected to 10 kN at 720 rpm. The bearing temperature is 65ºC and ambient temperature is 30oC. The journal diameter is 80 mm and l/d ratio is 1.2. Check whether artificial cooling is required or not.

Course Outcome 3 (CO3):

1. Explain the concept of slip and creep in belt drives.
2. It is required to select a flat belt drive for a fan running at 360 rpm which is driven by a 10kW, 1440 rpm motor. The belt drive is open type and space is available for a centre distance of 2 m approximately. The belt velocity should be between 17.8 to 22.9 m/s. The load correction factor can be taken as 1.2. Suggest preferred diameters for motor and fan pulleys and give complete specification of belting.
3. Select type of V-belt and number of belts required for 10kW, 750 rpm induction motor to drive an exhaust fan in a steel plant at 250 rpm. The center distance between shafts is 1.2 m. Pitch diameter of the motor pulley is 200mm.

Course Outcome 4 (CO4):

1. Explain interference and undercutting in gears.
2. Design a pair of spur gear to transmit 40 kW power with velocity ratio of 4.2:1. The pinion is rotating at 1000 rpm. The centre distance between parallel shafts is 120 mm. The allowable static stress for pinion and gear materials is 250 MPa and 200 MPa respectively.
3. Design a pair of helical gears to transmit 20 kW at 720 rpm of the pinion. A speed reduction ratio of 4 is required.

Course Outcome 5 (CO5)

1. What kind of contact occurs between worm and worm wheel? How does it differ from other types of gears?
2. A pair of bevel gears is required to transmit 30 kW at 500 rpm. The output shaft is running at 200 rpm and is at right angles to the input shaft. The gear is of cast iron and the pinion of cast steel. Design the gears.
3. Design a worm gear drive to transmit 15 kW at 1200 rpm. Speed reduction is 30:1. The worm is made of hardened steel and the wheel of phosphor bronze.

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: **B24ME3T06**

Course Name: **DESIGN OF MACHINE ELEMENTS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Explain torsional rigidity and lateral rigidity?
2 Differentiate between rigid and flexible couplings.
3 Differentiate hydro-dynamic and hydrostatic lubrication.
4 Define static and dynamic load bearing capacities of rolling contact bearing.
5 What are the desirable properties of a belt material from design point of view?
6 What are the advantages of leather belts over fabric rubber belts?
7 Explain two basic modes of gear tooth failure.
8 What is the main disadvantage of a single helical gear? What is the remedy?
9 How will you classify bevel gears on the basis of pitch angle?
10 Why usually worm and worm wheels are not made of same material?

PART B

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

Module 1

11 A mild steel shaft rotating at 900 rpm is supported between two bearings 800 mm apart. It carries two pulleys A and B at distance of 300 mm and 600 mm respectively from the left bearing. 12 kW of power is fed into the pulley A with a diameter of 400 mm and taken out at the pulley B with a diameter of 300 mm by vertical belt drives having the same ratio of driving tensions, which was observed to be 2.5. Design the diameter of the shaft assuming the working stresses in tension and shear as $\sigma_d = 75$ N/mm^2 and $\tau_d = 45$ N/mm^2. (14 marks)

OR

12 A rigid coupling is used to transmit 50 kW power at 300 rpm. There are 6 bolts. The outer diameter of the flanges is 200 mm, while the recess diameter is 150 mm. the coefficient of friction between the flanges is 0.15. the bolts are made of 45C8 (S_{yt} = 380N/mm^2) and

the factor od safety is 3. Determine the diameter of the bolts. Assume that the bolts are fitted in large clearance holes. (14 marks)

Module 2

13 Design a journal bearing to support a load of 5.5 kN at 650 rpm using hardened steel journal bronze backed babbitt bearing. The diameter of journal is 90 mm and the bearing is lubricated by oil rings. Consider room temperature as 22^0C and oil temperature as 85^0C. (14 marks)

OR

14 Select a suitable deep groove ball bearing for supporting a radial load of 10 kN and an axial load of 3 kN for a life of 4000 hours at 800 rpm. Select from SKF series 63. Calculate the expected life of the selected bearing. (14 marks)

Module 3

15 A flat belt drive is to transmit 15 hp at 1200 rpm from a driving shaft to driven shaft with a speed ratio of 4:1. The center-to-center distance between the pulleys is approximately 2.5 m. Design the belt drive if the diameter of driving shaft pulley is 150 mm. (14 marks)

OR

16 Select type of V-belt and number of belts required for 10kW, 750 rpm induction motor to drive an exhaust fan in a steel plant at 250 rpm. The center distance between shafts is 1.2 m. Pitch diameter of the motor pulley is 200mm. (14 marks)

Module 4

17 A pair of spur gears has to transmit 20 kW from a shaft rotating at 1300 rpm to a parallel shaft which is to rotate at 325 rpm. The material for pinion is steel with allowable static stress 200 MPa and the material for the gear is cast Iron with allowable static stress 120 MPa. (14 marks)

OR

18 Two helical gears are used in a speed reducer that is to driven by an internal combustion engine. The rated power of the speed reducer is 75 kW at a pinion rotational speed of 1200 rpm. The speed reduction ratio is 3:1. Assume medium shock conditions and 24 hours operation. Design the gear drive by selecting alloy steel for both pinion and gear wheel if the teeth are 200 full depth involute profile in the normal plane. (14 marks)

Module 5

19 A pair of straight bevel gears are to transmit 15 kW at 1500 rpm input speed. The number of teeth on the pinion is 20 and the speed ratio is 5. Design the gears assuming 14.5 0 full depth involute tooth profile. (14 marks)

OR

20 Design a worm gear drive for a speed reduction ratio of 25. The pinion rotates at 600 rpm and transmits 35 kW. (14 marks)

B24ME3T07	HEAT AND MASS TRANSFER	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course provides a rigorous understanding of the mechanisms of heat transfer (conduction, convection, and radiation) and mass transfer. The course is structured to first master each individual mode of heat transfer before progressing to the analysis and design of integrated thermal systems and the study of analogous mass transfer processes. Analytical and semi-empirical methods for solving engineering problems are emphasized.

Prerequisites

Nil

Course Outcomes

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

CO 1	Model and solve complex problems in steady-state and transient heat conduction. (Cognitive Knowledge Level: Apply)
CO 2	Apply boundary layer theory and dimensionless correlations to determine convective heat transfer coefficients for forced and natural convection. (Cognitive Knowledge Level: Apply)
CO 3	Apply radiation heat transfer principles to calculate radiative heat exchange between black and gray surfaces in various enclosures. (Cognitive Knowledge Level: Apply)
CO 4	Apply heat transfer principles to perform thermal analysis, rating, and preliminary design of heat exchangers and heat sinks. (Cognitive Knowledge Level: Apply)
CO 5	Apply the fundamental laws of mass transfer and leverage the heat-mass transfer analogy to solve diffusion and convection problems. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	10	10	10
Understand	30	30	30
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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Conduction Heat Transfer (9 hours)

Introduction to Heat Transfer - Modes, Applications. Fundamental Laws - Fourier's Law, Thermal Conductivity, Thermal Diffusivity. The General Heat Diffusion Equation (Cartesian, Cylindrical Coordinates). Boundary and Initial Conditions - Practical Examples.

One-Dimensional, Steady-State Conduction - The Plane Wall & Thermal Resistance Networks. One-Dimensional Conduction in Cylindrical Systems (Single and Composite). One-Dimensional Conduction in Spherical Systems; Critical Radius of Insulation.

Transient Conduction - The Lumped Capacitance Method (Criterion & Application). Transient Conduction in Large Plane Walls - Use of Heisler Charts.

Module 2: Convection Heat Transfer (9 hours)

Fundamentals of Convection - Physical Mechanism, Boundary Layer Concepts.

The Convection Transfer Equations - A Brief Overview of Governing Equations. Similarity Parameters - Reynolds, Prandtl, Nusselt, and their Physical Significance.

External Flow - Hydrodynamic and Thermal Boundary Layers on a Flat Plate. Empirical Correlations for Laminar and Turbulent Flow over Flat Plates. Flow over Bluff Bodies (Cylinders, Spheres). Flow across Tube Banks (Industrial Applications).

Internal Flow - Hydrodynamic and Thermal Entry Lengths, Mean Temperature. Internal Flow - Correlations for Laminar and Turbulent Flow in Pipes.

Natural Convection - Physical Mechanism, Grashof and Rayleigh Numbers. Natural Convection Correlations for Vertical, Horizontal, and Inclined Plates. Combined Forced and Natural Convection Problems.

Module 3: Thermal Radiation (9 hours)

Fundamentals of Thermal Radiation - Blackbody Radiation, Planck's, Wien's Displacement Laws. Radiative Properties - Emissivity, Absorptivity, Reflectivity, Transmissivity (Real Surfaces). The Stefan-Boltzmann Law; Kirchhoff's Law; The Gray Surface Approximation.

View Factor - Definition, Calculation, and Rules (Reciprocity, Summation, Superposition). Radiation Exchange between Black Surfaces. The Radiosity Method - Introduction and Formulation for Gray Surfaces. Radiation Exchange in Two-Surface and Three-Surface Enclosures. Radiation Shields and Reradiating Surfaces.

Module 4: Heat Exchangers and Heat Sinks (9 hours)

Introduction to Heat Exchangers - Types, Flow Arrangements (Parallel, Counter, Cross). Heat Exchanger Analysis : The Log Mean Temperature Difference (LMTD) Method. The NTU-Effectiveness Method. Comparison and Selection of LMTD vs. NTU Methods; Performance Evaluation. Case Study: Design and Analysis of a steam condenser for a thermal power plant.

Extended Surfaces (Fins) - The Fin Equation and Boundary Conditions. Fin Performance - Fin Efficiency, Effectiveness, and Applications. Case study: Heat sinks for Electronics cooling

Module 5: Mass Transfer and Applications (9 hours)

Introduction to Mass Transfer - Analogy with Heat Transfer, Fick's Law of Diffusion. Diffusion in Stationary and Moving Media; Convective Mass Transfer Coefficients. Dimensionless Numbers in Mass Transfer (Schmidt, Sherwood). Case Study: Diffusion in Heat treatment of steels, Combined Heat and Mass Transfer (e.g., Cooling Towers, Humidification, Drying).

Text Books

1. Incropera, F. P., DeWitt, D. P., Bergman, T. L., and Lavine, A. S., *Fundamentals of Heat and Mass Transfer*, Wiley.
2. Mahesh M. Rathore, *Engineering Heat and Mass Transfer*, Laxmi Publications.
3. Kothandaraman, C. P., *Heat and Mass Transfer Data Book*, New Age International Publishers.

Reference Books

1. Yunus A. Çengel and Afshin J. Ghajar, *Heat and Mass Transfer: Fundamentals & Applications*, McGraw Hill.
2. Holman, J. P., *Heat Transfer*, McGraw Hill.
3. R. C. Sachdeva, *Fundamentals of Engineering Heat and Mass Transfer*, New Age International Publishers.
4. C. P. Kothandaraman and S. Subramanyan, *Heat and Mass Transfer Data Book*, New Age International Publishers.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**9**
1.1	Introduction to Heat Transfer – Modes & Applications	1
1.2	Fourier's Law of Conduction	1
1.3	Thermal Conductivity & Thermal Diffusivity	1
1.4	General Heat Diffusion Equation – Cartesian Coordinates	1
1.5	General Heat Diffusion Equation – Cylindrical Coordinates	1
1.6	Boundary and Initial Conditions – Practical Examples	1
1.7	1D Steady Conduction – Plane Wall, Thermal Resistance Network	1
1.8	Cylindrical & Spherical Conduction, Composite Systems	1
1.9	Critical Radius of Insulation & Introduction to Transient Conduction	1
	Module 2	**9**
2.1	Physical Mechanism of Convection & Boundary Layers	1

2.2	Governing Equations & Similarity Parameters (Re, Pr, Nu)	1
2.3	Flat Plate Flow – Hydrodynamic Boundary Layer	1
2.4	Flat Plate Flow – Thermal Boundary Layer	1
2.5	Forced Convection Correlations – Laminar Plate	1
2.6	Forced Convection Correlations – Turbulent Plate	1
2.7	Flow over Cylinders & Spheres	1
2.8	Flow across Tube Banks – Industrial Cases	1
2.9	Internal Flow – Entry Lengths, Mean Temp & Pipe Flow Correlations	1
	Module 3	**9**
3.1	Fundamentals – Blackbody Concepts	1
3.2	Planck's Law, Wien's Displacement Law	1
3.3	Emissivity, Absorptivity, Reflectivity, Transmissivity	1
3.4	Stefan-Boltzmann Law & Kirchhoff's Law	1
3.5	Gray Surface Approximation	1
3.6	View Factors – Rules & Determination Methods	1
3.7	Radiation Exchange between Black Surfaces	1
3.8	Radiosity Method for Gray Surfaces	1
3.9	Radiation Shields & Reradiating Surfaces	1
	Module 4	**9**
4.1	Heat Exchangers – Classification & Flow Arrangements	1
4.2	LMTD Method – NTU Method Overview	1
4.3	Effectiveness-NTU Method – Design Procedure	1
4.4	Performance Evaluation & Selection	1
4.5	Case Study – Steam Condenser Design	1
4.6	Introduction to Fins & Fin Equation	1
4.7	Fin Boundary Conditions	1
4.8	Fin Efficiency & Effectiveness	1
4.9	Case Study – Heat Sinks for Electronic Cooling	1
	Module 5	**9**
5.1	Introduction to Mass Transfer – HMT Analogy	1
5.2	Fick's Law of Diffusion	1
5.3	Diffusion in Stationary and Moving Media	1
5.4	Convective Mass Transfer Coefficient	1
5.5	Dimensionless Numbers (Sc, Sh)	1
5.6	Combined Heat & Mass Transfer Concepts	1
5.7	Cooling Towers – Theory & Operation	1
5.8	Humidification & Drying	1
5.9	Case Study – Diffusion in Heat Treatment of Steels	1
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Derive the general heat diffusion equation in Cartesian coordinates and state the assumptions made.
2. A hollow sphere of inner radius 5 cm and outer radius 10 cm has a thermal conductivity of 25 W/m·K. Determine the heat transfer rate if the inner and outer surface temperatures are 200°C and 50°C respectively.
3. Explain the concept of critical radius of insulation with a practical example.

Course Outcome 2 (CO2):

1. Define hydrodynamic and thermal boundary layers and illustrate their growth over a flat plate with a neat sketch.
2. Air at 20°C flows over a flat plate at 1.5 m/s and length 1 m. Estimate the average convective heat transfer coefficient using a suitable correlation.
3. Compare forced convection and natural convection in terms of governing dimensionless numbers and physical significance.

Course Outcome 3 (CO3):

1. State and explain the Stefan–Boltzmann law for thermal radiation between two surfaces.
2. A surface at 700 K with emissivity 0.8 emits radiant energy. Calculate the heat flux emitted.
3. What are view factors? Explain reciprocity and summation rules with a simple example.

Course Outcome 4 (CO4):

1. Explain the LMTD method for parallel and counter-flow heat exchangers with appropriate sketches.
2. A heat exchanger has NTU = 2.5 and Cmin/Cmax = 0.6. Determine its effectiveness for a counter-flow arrangement.
3. Define fin efficiency and fin effectiveness and explain when a fin becomes ineffective for heat transfer enhancement.

Course Outcome 5 (CO5)

1. State Fick's law of diffusion and derive the expression for steady diffusion through a plane wall.
2. Calculate the mass diffusion rate of a gas through stagnant film using suitable given data.
3. Explain the role of mass transfer in cooling towers and how it couples with heat transfer.

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: **B24ME3T07**

Course Name: **HEAT AND MASS TRANSFER**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Define thermal diffusivity and write its significance.
2 What is thermal contact resistance? Give one practical example.
3 State the physical meaning of the Nusselt number.
4 What is the difference between hydrodynamic entry length and thermal entry length?
5 Define emissivity. How does it differ from absorptivity?
6 Write Kirchhoff's law of radiation and its engineering importance.
7 Define effectiveness of a heat exchanger.
8 What is the purpose of using fins on heat transfer surfaces?
9 State Fick's first law of diffusion.
10 Write any two applications of combined heat and mass transfer in industry.

PART B

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

Module 1

11 Derive the general heat diffusion equation in Cartesian coordinates. Explain the significance of each term and list the assumptions involved in the derivation. (14 Marks)

OR

12 A plane wall of thickness 200 mm has its surfaces maintained at 180°C and 60°C. The thermal conductivity of the wall is 8 W/m·K. Calculate:
(a) The heat transfer rate per unit area
(b) The temperature gradient in the wall. (14 Marks)

Module 2

13 Explain boundary layer growth over a flat plate with neat sketches. Derive the expression for local heat transfer coefficient in laminar flow over a flat plate. (14 Marks)

OR

14 Air at 50°C flows over a flat plate 2 m long at a velocity of 3 m/s. The plate surface temperature is 120°C. Determine:
(a) The Reynolds number at the trailing edge
(b) The average Nusselt number
(c) The heat transfer coefficient
Take properties at film temperature. (14 Marks)

Module 3

15 Discuss the laws governing thermal radiation and explain the concept of a gray surface. Show how the radiation heat exchange formula is modified when real surfaces are involved. (14 Marks)

OR

16 Two infinite parallel plates at temperatures 900 K and 600 K have emissivities 0.8 and 0.6 respectively. Calculate the net radiation heat exchange per unit area between the surfaces using the radiation network approach. (14 Marks)

Module 4

17 With neat diagrams, explain the LMTD method for parallel-flow and counter-flow heat exchangers. Discuss the limitations of LMTD and how the correction factor is used. (14 Marks)

OR

18 In a counter-flow heat exchanger, hot water enters at 90°C and leaves at 50°C, while cold water enters at 25°C and leaves at 40°C. The heat capacity rates are Cmin = 2500 W/K and Cmax = 4800 W/K. Calculate:
(a) Effectiveness of the heat exchanger
(b) Number of Transfer Units (NTU) (14 Marks)

Module 5

19 Derive Fick's law of diffusion for steady one-dimensional diffusion through a solid slab. State assumptions and boundary conditions clearly. (14 Marks)

OR

20 A gas A diffuses through non-diffusing B. The partial pressure of A at two positions 4 mm apart is 700 mmHg and 300 mmHg. Total pressure is 900 mmHg. Temperature is 27°C. The diffusion coefficient is 1.8×10^{-5} m²/s. Calculate the molar flux of A. (14 Marks)

B24ME3T08	FINITE ELEMENT METHODS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course introduces undergraduate students to the fundamental principles of Finite Element formulation. It focuses on numerical techniques for solving field problems by developing formulation schemes that lead to matrix equations suitable for computer-based solutions. By understanding the basics of finite element formulation, students gain insight into the scope, capabilities, and limitations of different modelling choices, such as the selection of appropriate element types for a given problem.

Prerequisite

Nil

Course Outcomes

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

CO 1	Explain the basic concepts, terminology, engineering applications, and procedural steps of the Finite Element Method, including material properties, boundary conditions, and fundamental elasticity relations. (Cognitive Knowledge Level: Understand)
CO 2	Apply numerical and energy-based methods such as the Potential Energy, Rayleigh–Ritz, and Galerkin methods to solve simple one-dimensional structural problems. (Cognitive Knowledge Level: Apply)
CO 3	Derive and apply shape functions for one- and two-dimensional finite elements using polynomial expressions, natural coordinates, and coordinate transformation techniques. (Cognitive Knowledge Level: Apply)
CO 4	Model strain–displacement relationships (B-matrix), assemble stiffness matrices for basic finite elements, and apply meshing concepts for simple structural models. (Cognitive Knowledge Level: Apply)
CO 5	Model and analyze basic structural and thermal engineering problems using energy principles and simple computational tools. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	20	10	10
Understand	40	30	30
Apply	40	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Introduction to Finite Element Method (10 hours)

Introduction to FEM - Engineering applications, advantages, General steps, Element types, Convergence criteria, Coordinate systems, commercial packages, pre-processor, solver and postprocessor.

Material Properties and Boundary Conditions - E, G & ν, Material Classification, Material Properties, Boundary Conditions, How to Apply Constraints, Symmetry. Principles of Elasticity: Strain displacement relations, Stress strain relations for 1D, 2D, and 3D cases, Plain stress and Plain strain conditions.

MODULE 2: Numerical Methods, Elements and Stiffness Formulation (10 hours)

Introduction to Numerical Methods, Potential energy method, Rayleigh-Ritz method and Galerkin method applied to simple problems on axially loaded members, simply supported beams, with point loads.

Types of finite elements and their characteristics, Formulation of stiffness matrix for one-dimensional spring and bar elements, Element assembly and global stiffness matrix formation, Solution procedures for finite element equations.

MODULE 3: Shape Functions and Displacement Models (9 hours)

Coordinate systems in FEM and coordinate transformation. Concept and properties of shape functions, Derivation of shape functions using polynomial expressions: One-dimensional bar element, Two-dimensional Constant Strain Triangle (CST) element, Convergence requirements of shape functions, Pascal's triangle and its application in shape function formulation, Shape functions using Lagrange interpolation polynomials.

MODULE 4: Strain–Displacement Relationship, Introduction to Meshing (9 hours)

Derivation of strain–displacement relationships (B-matrix) for bar and CST elements, Potential energy and conditions for equilibrium.

Meshing process, types of elements, deciding element type, using 1-d, 2-d, 3-d elements, deciding element length, meshing techniques, meshing in critical areas. Using 1-d elements, stiffness matrix derivation, stiffness matrix- assembly of two-node elements.

MODULE 5: Energy Principles and Case Study (7 hours)

Principle of minimum potential energy, Variational formulation in FEM, Element stiffness matrices for bar and beam elements.

Case Study I: Modelling a bar subjected to axial loads and determining its displacement and reaction forces using Python

Case Study II: Steady-state heat conduction in a bar

Text Books

1. Chandrupatla, T. R., & Belegundu, A. D., *Introduction to finite elements in engineering*, Pearson Education.

2. Rao, S. S., *The finite element method in engineering,* Butterworth-Heinemann.
3. Reddy, J. N., *An introduction to the finite element method,* McGraw-Hill Education.

Reference Books

1. Zienkiewicz, O. C., Taylor, R. L., & Zhu, J. Z., *The finite element method: Its basis and fundamentals* Elsevier.
2. Bathe, K.-J, *Finite element procedures*, Prentice Hall.
3. Logan, D. L. *A first course in the finite element method*, Cengage Learning.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module1	**10**
1.1	Introduction to FEM, Engineering applications, and advantages	1
1.2	General steps, Element types, Convergence criteria, Coordinate systems	2
1.3	commercial packages, pre-processor, solver and postprocessor.	1
1.4	Material Properties and Boundary Conditions - E, G & ν, Material Classification	1
1.5	Boundary Conditions, Applying Constraints, Symmetry	1
1.6	Principles of Elasticity: Strain displacement relations	2
1.7	Stress strain relations for 1D, 2D, and 3D cases, Plain stress and Plain strain conditions	2
	Module 2	**10**
2.1	Introduction to Numerical Methods, Potential energy method	1
2.2	Rayleigh-Ritz method applied to simple problems on axially loaded members, simply supported beams, with point loads.	2
2.3	Galerkin method applied to simple problems on axially loaded members, simply supported beams, with point loads.	2
2.4	Types of finite elements and their characteristics	1
2.5	Formulation of stiffness matrix for one-dimensional spring and bar elements	1
2.6	Element assembly and global stiffness matrix formation	2
2.7	Solution procedures for finite element equations.	1
	Module 3	**9**
3.1	Coordinate systems in FEM and coordinate transformation	1
3.2	Concept and properties of shape functions	1
3.3	Derivation of shape functions using polynomial expressions: One-dimensional bar element	2
3.4	Derivation of shape functions using polynomial expressions: Two-dimensional Constant Strain Triangle (CST) element	2
3.5	Convergence requirements of shape functions, Pascal's triangle and its application in shape function formulation	2
3.6	Shape functions using Lagrange interpolation polynomials.	1

	Module 4	**9**
4.1	Meshing process, types of elements	1
4.2	Deciding element type, using 1-d, 2-d, 3-d elements	2
4.3	Deciding on element length, meshing techniques, and meshing in critical areas.	1
4.4	Using 1-d elements, stiffness matrix derivation, Stiffness matrix- assembly of two rod elements	2
4.5	Derivation of strain–displacement relationships (B-matrix) for bar and CST elements, Potential energy and conditions for equilibrium	3
	Module 5	**7**
5.1	Principle of minimum potential energy, Variational formulation in FEM, Element stiffness matrices for bar and CST elements	3
5.2	Case Study I: Modelling a bar subjected to axial loads and determining its displacement and reaction forces using Python	2
5.3	Case Study II: Steady-state heat conduction in a bar.	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. List and briefly explain three engineering applications of the Finite Element Method (FEM)
2. What are the general steps involved in the FEM analysis process? Outline them in sequence.
3. Explain the role of the pre-processor, solver, and post-processor in commercial FEM packages.

Course Outcome 2 (CO2):

1. 1.What are the main differences between the Galerkin method and the Rayleigh-Ritz method in the context of finite element approximations for simple beam problems?
2. Describe the characteristics of a one-dimensional bar element used in FEM for axially loaded members.
3. State the basic form of the stiffness matrix for a one-dimensional spring element and explain how it relates to the spring constant.

Course Outcome 3 (CO3):

1. Explain the concept of coordinate transformation in FEM and its necessity when dealing with elements in different coordinate systems.
2. List and briefly describe the key properties that shape functions must satisfy in the finite element method.
3. Describe the role of Pascal's triangle in the formulation of shape functions for polynomial approximations.

Course Outcome 4 (CO4):

1. Derive the strain-displacement relationship (B-matrix) for a one-dimensional two-node bar element in terms of nodal displacements.
2. List and briefly describe three common meshing techniques used in FEM, highlighting their applicability to critical areas.
3. What factors should be considered when deciding between 1D, 2D, and 3D elements for modeling a structural component? Provide an example.

Course Outcome 5 (CO5):

1. State the principle of minimum potential energy and explain how it leads to the equilibrium conditions in structural analysis.
2. Describe the key steps in the variational formulation of the finite element method for a general boundary value problem.
3. What are the main differences in the stiffness matrix formulation between a bar element and a beam element?

KNOWLEDGE IS POWER

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SIXTH SEMESTER B TECH DEGREE EXAMINATION, MAY 2027

Course Code: **B24ME3T08**

Course Name: **FINITE ELEMENT METHODS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1) What are the general steps involved in the FEM analysis process? Outline them in sequence.
2) Explain the role of the pre-processor, solver, and post-processor in commercial FEM packages.
3) What are the main differences between the Galerkin method and the Rayleigh-Ritz method in the context of finite element approximations for simple beam problems?
4) State the basic form of the stiffness matrix for a one-dimensional spring element and explain how it relates to the spring constant.
5) Explain the concept of coordinate transformation in FEM and its necessity when dealing with elements in different coordinate systems.
6) List and briefly describe the key properties that shape functions must satisfy in the finite element method.
7) Derive the strain-displacement relationship (B-matrix) for a one-dimensional two-node bar element in terms of nodal displacements.
8) List and briefly describe three common meshing techniques used in FEM, highlighting their applicability to critical areas.
9) In the context of steady-state heat conduction, explain how the variational principle is analogous to the minimum potential energy in structural mechanics.
10) Describe the key steps in the variational formulation of the finite element method for a general boundary value problem.

PART B

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

Module 1

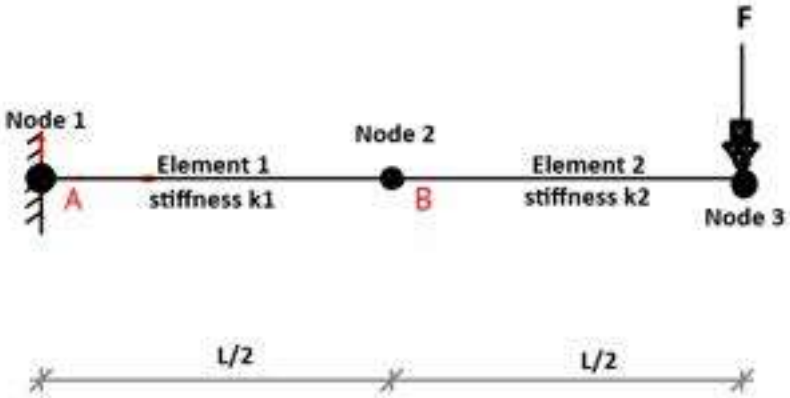
11) Describe the principles of elasticity in the context of FEM, including strain-displacement relations and stress-strain relations for 1D, 2D, and 3D cases. (14 marks)

OR

12) Explain how material properties and boundary conditions are incorporated into FEM models. Discuss material classification, methods to apply constraints, and the use of symmetry to simplify analyses. (14 marks)

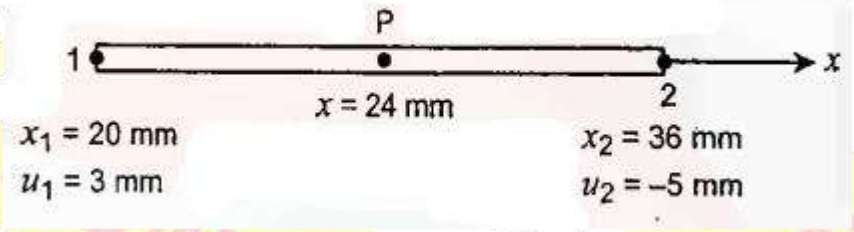
Module 2

13) A truss structure consists of two bar elements connected in series as shown in the figure: Element 1 (length L/2, stiffness k1) from node 1 (fixed) to node 2, and Element 2 (length L/2, stiffness k2) from node 2 to node 3 (free end with load F). Derive the stiffness matrices for each bar element, assemble the global stiffness matrix, apply boundary conditions, and solve for the nodal displacements at nodes 2 and 3. (14 marks)



OR

14) A one-dimensional bar is shown in figure. Calculate the following:
(i) Shape function N_1 and N_2 at point P.
(ii) If $U_1 = 3$ mm and $U_2 = -5$ mm, calculate the displacement U at point P.



(14 marks)

Module 3

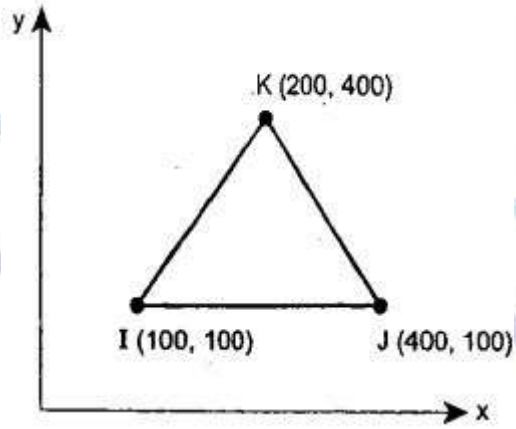
15) For a two-dimensional Constant Strain Triangle (CST) element with nodes at (0,0), (1,0), and (0,1), derive the shape functions using linear polynomial expressions in natural coordinates. (14 marks)

OR

16) Derive the displacement function u and shape function N for a one-dimensional linear bar element. (14 marks)

Module 4

17) For the constant strain triangular element shown in the figure, assemble the strain-displacement matrix. Take thickness, t = 20 mm and E = 2 x 10^5 N/mm^2. (14 marks)



OR

18) a. For a 2D stress analysis problem employing a three-noded triangular element, with vertices at (0,1), (0,-1) and (2,0), evaluate the Strain-Displacement Matrix. (5 marks)

b. For a Constant Strain Triangle (CST) element with nodes at coordinates (x_1,y_1), (x_2,y_2), (x_3,y_3), derive the B-matrix relating strains to nodal displacements. (9 marks)

Module 5

19) Consider a uniform bar of length L = 1 m, area A = 0.005 m^2, and E = 210 GPa, fixed at the left end (node 1) and free at the right end (node 2) with an axial load F = 5 kN at node 2. Model it as a single two-node bar element: derive the stiffness matrix, apply boundary conditions, solve for the displacement at node 2, and compute the reaction force at the fixed end. (14 marks)

OR

20) A uniform bar of length L = 0.5 m, cross-sectional area A = 0.002 m^2, and thermal conductivity k = 50 W/m·K is subjected to steady-state heat conduction with fixed temperatures T1 = 100°C at x=0 and T2 = 0°C at x=L (no internal heat generation). Model it using FEM with a single linear 'heat conduction' element analogous to an axial bar. (14 marks)

KNOWLEDGE IS POWER

B24ME3T09	ADVANCED AUTOMOTIVE SYSTEMS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble:

This course provides a comprehensive understanding of internal combustion engines with emphasis on their construction, working principles, combustion processes, and performance characteristics. It covers spark-ignition and compression-ignition engines, fuel supply and ignition systems, combustion phenomena, and emission formation mechanisms. The course also introduces modern engine technologies including electronic engine management systems, sensors, and emission control strategies aimed at improving performance and reducing environmental impact. Through this course, students develop the ability to analyze engine behavior, understand regulatory emission requirements, and appreciate current trends in automotive engine technology.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the construction, working principles, classifications, and thermodynamic cycles of spark-ignition and compression-ignition engines, including recent combustion technologies. (Cognitive Knowledge Level: Understand)
CO 2	Apply air–fuel preparation principles, ignition systems, and combustion concepts to analyze performance, knocking, and emission characteristics of SI engines with electronic control. (Cognitive Knowledge Level: Apply)
CO 3	Analyze diesel fuel injection systems, air motion, and combustion phenomena to evaluate performance, ignition delay, and emission characteristics of CI engines. (Cognitive Knowledge Level: Apply)
CO 4	Explain engine design strategies, after-treatment technologies, and emission measurement techniques to control and evaluate automotive exhaust emissions. (Cognitive Knowledge Level: Understand)
CO 5	Apply sensors, ECUs, diagnostics, and electronic engine management concepts to understand modern automotive engine control and monitoring systems. (Cognitive Knowledge Level: Apply).

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	3	1	1								1
CO 2	3	3	1		1						
CO 3	3	3	1		1						
CO 4	2	2	2	1	1	2					1
CO 5	2	2	1		3				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	30
Apply	40	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: IC Two Stroke and Four Stroke Engines (8 Hours)

Working and constructional details of four stroke and two stroke spark ignition (SI) and compression ignition (CI) engines, working principles and comparison. Engine classifications, firing order. Otto, diesel and dual cycles. Introduction to Lean burn combustion technologies, Multi fuel engines and stratified charge engines.

MODULE 2: Air Fuel Requirements, Combustion and Emission in SI engines (9 Hours)

Air fuel ratio requirements - Carburetion principle, Throttle body injection, Multi point injection. Function of Components, Spark plug, Ignition System - battery coil, magneto coil and electronic ignition systems.

Combustion in SI Engines - Combustion Chambers, Stages of Combustion - factors affecting flame propagation, Knock in SI engines, Knock reduction factors.

Computer control of SI & CI engines for better performance and low emissions, Closed loop control of engine parameters of fuel injection and ignition, Combined ignition and fuel management systems.

Pollution from SI engines.

MODULE 3: Diesel Engine Working Features (9 Hours)

Diesel fuel injection system, Function of injection Components, High pressure fuel pumps, Fuel Injector, DI, IDI and CRDI engines Types of nozzles, importance of Swirl, Squish, Turbulence air motion, Combustion in CI Engines - Combustion Chambers, Factors affecting Ignition Delay, Detonation in CI engines. Fuel spray characteristics and combustion in diesel engines.

Pollution from CI engines.

MODULE 4: Pollution Control and Measurement methods (9 Hours)

Design of engine, optimum selection of operating variables for control of emissions, EGR, charge stratification, SCR, DPF, Lean NOX catalyst technology. Thermal reactors, secondary air injection, catalytic converters, catalysts, fuel modifications.

Pollution measurements- NDIR, FID and Chemiluminescence analyzers, Gas Chromatograph, smoke meters, Latest emission standards.

MODULE 5: Engine Electronics and Management Systems (10 Hours)

Current trends in automotive electronic engine management system- Types of sensors: sensor for speed, throttle position, exhaust oxygen level, manifold pressure, crankshaft position, coolant temperature, exhaust temperature, air mass flow for engine application.

Engine Electronics and Engine Management: ECU, Mapping and Onboard diagnostics, Electromagnetic interference suppression and electromagnetic compatibility, electronic dashboard instruments, security and warning systems.

Introduction to EV Technology, EV and HEV vehicles. Advantages of Hybrid vehicles.

Text Books

1. Heinz Heisler, *Vehicle and engine technology*, Butterworth-Heinemann (Elsevier), 2nd Edition, 2002.
2. Kirpal Singh, *Automobile Engineering Vol.1 & Vol. 2,* Standard Publishers.

Reference Books

1. William B Ribbens, *Understanding Automotive Electronics*, 6th Edition, Elsevier Publishing.
2. Robert Bosch GmbH (Ed.), *Bosch Automotive Electrics and Automotive Electronics Systems and Components, Networking and Hybrid Drive*, John Wiley & Sons Inc.
3. V.A.W. Hillier, *Fundamentals of modern vehicle technology*, Butterworth-Heinemann.
4. Shimo Kim and Rakesh Shresta, *Automotive Cyber Security: Introduction Challenges and Standardization*, Springer, Singapore.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**8**
1.1	Working and constructional details of four stroke and two stroke spark ignition (SI) and compression ignition (CI) engines.	2
1.2	Working principles and comparison of 2S and 4S Engines.	1
1.3	Working principles and comparison of 2S and 4S Engines.	1
1.4	Engine classifications, firing order.	1
1.5	Otto, diesel and dual cycles.	1
1.6	Lean burn combustion technologies, Multi fuel engines and stratified charge engines.	1
1.7	Lean burn combustion technologies, Multi fuel engines and stratified charge engines.	1
	Module 2	**9**
2.1	Air fuel ratio requirements - Carburetion principle, Throttle body injection.	2
2.2	Function of Components, Spark plug, Ignition System - battery coil, magneto coil and electronic ignition systems.	1
2.3	Combustion in SI Engines - Combustion Chambers, Stages of Combustion.	1
2.4	Factors affecting flame propagation, Knock in SI engines, Knock reduction factors.	1
2.5	Computer control of SI & CI engines for better performance and low emissions.	1
2.6	Closed loop control of engine parameters of fuel injection and ignition.	1

2.7	Combined ignition and fuel management systems.	1
2.8	Pollution from SI engines.	1
	Module 3	**9**
3.1	Diesel fuel injection system, Function of injection Components.	2
3.2	High pressure fuel pumps, Fuel Injector.	1
3.3	DI, IDI and CRDI engines Types of nozzles.	1
3.4	Importance of Swirl, Squish, Turbulence air motion.	1
3.5	Combustion in CI Engines - Combustion Chambers	1
3.6	Factors affecting Ignition Delay, Detonation in CI engines.	1
3.7	Fuel spray characteristics and combustion in diesel engines.	1
3.8	Pollution from CI engines.	1
	Module 4	**9**
4.1	Design of engine, optimum selection of operating variables for control of emissions.	2
4.2	EGR, charge stratification, SCR, DPF, Lean NOX catalyst technology.	1
4.3	Thermal reactors, secondary air injection, catalytic converters.	1
4.4	Thermal reactors, secondary air injection, catalytic converters.	1
4.5	Catalysts, fuel modifications.	1
4.6	Pollution measurements- NDIR, FID and Chemiluminescence analyzers.	1
4.7	Chemiluminescence analyzers, Gas Chromatograph.	1
4.8	Smoke meters, Latest emission standards.	1
	Module 5	**10**
5.1	Current trends in automotive electronic engine management system.	2
5.2	Types of sensors: sensor for speed, throttle position.	2
5.3	Types of sensors: sensor for exhaust oxygen level, manifold pressure for engine application.	1
5.4	Types of sensors: sensor for crankshaft position, coolant temperature, exhaust temperature, air mass flow for engine application.	1
5.5	Engine Electronics and Engine Management: ECU, Mapping and onboard diagnostics.	1
5.6	Electromagnetic interference suppression and electromagnetic compatibility.	1
5.7	Electronic dashboard instruments, security and warning systems.	1
5.8	Introduction to EV Technology, EV and HEV vehicles. Advantages of Hybrid vehicles.	1
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Which of the following best explains why a two-stroke engine typically has a higher power-to-weight ratio than a four-stroke engine of similar displacement?
2. How does the Dual Cycle model provide a more realistic representation of modern high-speed Diesel engines compared to the standard Diesel cycle?
3. Why is the thermal efficiency of an Otto cycle generally higher than a Diesel cycle for the same compression ratio?

Course Outcome 2 (CO2):

1. Explain how the carburetion principle ensures the correct air-fuel ratio for different engine operating conditions.
2. Explain how closed-loop computer control of fuel injection and ignition helps reduce emissions in SI engines.
3. Discuss the factors that affect flame propagation in SI engines and explain how these factors contribute to engine knock.

Course Outcome 3 (CO3):

1. Explain DI and IDI engines.
2. Explain Detonation in diesel engines.
3. Mention the major pollutants from diesel engines.

Course Outcome 4 (CO4):

1. What is Squish and Swirl motion in engines?
2. Explain how chemiluminescence analyzers are used for NOx measurement and how gas chromatographs help in analyzing exhaust gas composition.
3. Explain how thermal reactors and secondary air injection systems contribute to reducing hydrocarbon and carbon monoxide emissions.

Course Outcome 5 (CO5)

1. Explain how speed sensors and throttle position sensors contribute to efficient engine management.
2. Describe the role of exhaust oxygen sensors and manifold pressure sensors in maintaining the correct air-fuel ratio.
3. Discuss how crankshaft position, coolant temperature, exhaust temperature, and air mass flow sensors provide critical inputs for ECU operation.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

FIFTH SEMESTER B TECH DEGREE EXAMINATION, DEC 2026

Course Code: **B24ME3T09**

Course Name: **ADVANCED AUTOMOTIVE SYSTEMS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. In the context of multi-cylinder engines, what is the primary purpose of establishing a specific Firing Order?
2. Identify the difference between SI and CI engine.
3. What are the factors affecting the flame propagation in engines.
4. What is Knocking in engines and comment on its undesirable effects.
5. Describe the importance of swirl, squish, and turbulence in promoting efficient combustion in compression ignition engines.
6. Explain how optimum selection of operating variables in engine design helps in reducing harmful emissions.
7. Describe the role of Exhaust Gas Recirculation (EGR) and Selective Catalytic Reduction (SCR) in controlling NOx emissions.
8. Discuss how catalytic converters and fuel modifications work together to minimize exhaust pollutants.
9. Describe why electromagnetic interference suppression and electromagnetic compatibility are important in modern automotive electronics.
10. Discuss the importance of electronic security and warning systems in improving vehicle safety and reliability.

PART B

Answer all questions. Each question carries 14 marks.

Module 1

11. Discuss the factors that affect flame propagation in SI engines and explain how these factors contribute to engine knock. (14 Marks)

OR

12. Compare the working of battery coil ignition and magneto coil ignition systems, highlighting their advantages and limitations. (14 Marks)

Module 2

13. With a neat sketch explain conventional ignition system. (14 Marks)

OR

14. Explain different types of Combustion chamber designs for SI engines. (14 Marks)

Module 3

15. Explain how fuel spray characteristics and combustion processes in diesel engines contribute to pollutant formation. (14 Marks)

OR

16. Discuss the factors that influence ignition delay in CI engines and explain how they affect combustion chamber performance. (14 Marks)

Module 4

17. Describe the function of smoke meters in measuring particulate emissions and explain the importance of adhering to the latest emission standards. (14 Marks)

OR

18. Compare the working principles of Non-Dispersive Infrared (NDIR) analyzers and Flame Ionization Detectors (FID) in measuring exhaust emissions. (14 Marks)

Module 5

19. Explain how the Engine Control Unit (ECU) uses mapping and onboard diagnostics to optimize engine performance. (14 Marks)

OR

20. Explain how electronic dashboard instruments enhance driver awareness and vehicle monitoring compared to traditional mechanical gauges. (14 Marks)

B24ME3P21	MAINTENANCE MANAGEMENT AND RELIABILITY ENGINEERING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course on Maintenance Management and Reliability Engineering introduces mechanical engineering students to the principles, methods and tools required to ensure dependable, safe and cost-effective operation of engineering assets. Covering maintenance systems, reliability analysis, planning and scheduling, failure pattern modelling and modern maintenance strategies, the syllabus blends theoretical concepts with practical techniques. Students will learn to evaluate equipment performance, design maintenance interventions, apply reliability-based decision tools and address safety and economic aspects of maintenance. On completion, they will be able to contribute to improved asset availability, reduced life-cycle costs and safer industrial operations.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the objectives, functions, and types of maintenance systems and describe their role in improving equipment availability, cost efficiency, and safety. (Cognitive Knowledge Level: Understand)
CO 2	Apply reliability, availability, and maintainability concepts to evaluate system performance using MTBF, MTTR, failure rate, and reliability models. (Cognitive Knowledge Level: Apply)
CO 3	Develop basic maintenance plans, schedules, and spare parts management strategies using PM principles, inventory control methods, and CMMS concepts. (Cognitive Knowledge Level: Apply)
CO 4	Identify equipment failure patterns and model component life using Weibull distribution, bathtub curve behaviour, and system effectiveness factors. (Cognitive Knowledge Level: Apply)
CO 5	Explain TPM, RCM, safety procedures, and economic evaluation methods to support effective, safe, and cost-optimized maintenance decision-making. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	30	30	30
Understand	50	40	40
Apply	20	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Introduction to Maintenance Management and Systems (6 hours)

Definitions and scope of maintenance engineering- Objectives of maintenance: maximizing availability, minimizing cost, improving safety- Types of Maintenance: breakdown (corrective), preventive (time-based, usage-based), predictive (condition-based), reliability-centered maintenance, and total productive maintenance (TPM).

Module 2: Reliability Engineering and Analysis (7 hours)

Reliability definition- Reliability, availability and maintainability (RAM) concepts- Basic probability theory and distributions - failure rate, Mean Time Between Failures (MTBF), Mean Time to Repair (MTTR), system availability - System Reliability: analysis of series and parallel systems, redundancy, reliability estimation methods - Failure patterns and life-cycle characteristics- Failure Analysis: Failure Mode and Effect Analysis (FMEA), Fault Tree Analysis, Root Cause Analysis (RCA)- Applications of RAM analysis in mechanical equipment.

Module 3: Maintenance Planning, Scheduling, and Management Tools (8 hours)

Planning and scheduling: principles of planned maintenance, developing PM programs, maintenance scheduling (Gantt charts, priority systems)- Spare parts and inventory Control: objectives of inventory control, ABC analysis, VED analysis, two-bin systems, safety stock determination, methods for calculating spare requirements - Computerized Maintenance Management Systems (CMMS): benefits and applications of CMMS, plant registers, maintenance reports, overview of commercial software packages.

MODULE 4: Failure patterns and fitting curves (7 hours)

Failure patterns and bath tub curve - early failure period, constant failure period, the wear out failure period -the Weibull distribution: shape, scale parameters, estimation of Weibull parameters, Weibull probability plot, using Weibull to describe component life- Performance and cost factors: factors affecting reliability, availability utilization factor, system effectiveness- introduction to reliability growth models.

Module 5: Modern Maintenance Strategies and Safety (8 hours)

Total Productive Maintenance (TPM): goals and methodology of TPM, the 8 pillars, Overall Equipment Effectiveness (OEE) calculations, 5S principles -Reliability Centered Maintenance (RCM): principles, benefits, step-by-step procedures for RCM analysis, decision diagrams- Safety and economic aspects: safety engineering principles, lock-out/tag-out procedures, guidelines for improving safety in maintenance work, maintenance costing, life cycle costing, budgeting, maintenance audits – overview of condition monitoring technologies (vibration, thermography, oil analysis).

Textbooks

1. A. K. Gupta & K. C. Khanna, *Maintenance Engineering and Management*, S. Chand Publishing
2. S. K. Srivastava, *Industrial Maintenance Management*, S. Chand.
3. Charles E. Ebeling, *An Introduction to Reliability and Maintainability Engineering*, McGraw-Hill.

References

1. R. Keith Mobley, *Maintenance Engineering Handbook*, McGraw-Hill
2. John Moubray, *Reliability-Centered Maintenance (RCM)*, Industrial Press
3. D. J. Smith, *Reliability, Maintainability and Risk*, Butterworth-Heinemann

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**6**
1.1	Introduction, scope, objectives of maintenance – availability, cost, safety	2
1.2	Breakdown, preventive (time/usage-based) maintenance	2
1.3	Predictive, RCM, TPM – introduction & comparison	2
	Module 2	**7**
2.1	Reliability, availability, maintainability (RAM) concepts	2
2.2	Probability basics, MTBF, MTTR, failure rate	2
2.3	Series & parallel reliability, redundancy, estimation methods	2
2.4	FMEA, FTA, RCA – introduction & examples	1
	Module 3	**8**
3.1	Principles of planning & scheduling, PM program design	2
3.2	Inventory & spare parts management – ABC, VED, two-bin, safety stock	2
3.3	CMMS – functions, reports, software overview	2
3.4	Spare requirement calculations, plant registers, documentation	2
	Module 4	**7**
4.1	Failure patterns, bathtub curve	2
4.2	Weibull distribution – shape, scale, parameters	2
4.3	Weibull probability plot – interpretation & examples	2
4.4	System effectiveness, utilization factor, reliability growth	1
	Module 5	**8**
5.1	TPM – goals, pillars, 5S, OEE calculation	2
5.2	RCM – principles, steps, decision diagrams	2
5.3	Safety engineering, LOTO, risk assessment	2
5.4	Costing, LCC, budgeting, maintenance audits, condition monitoring	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. List any three objectives of maintenance.
2. Differentiate between breakdown and preventive maintenance.
3. Discuss the objectives, functions, and significance of maintenance management in modern industries.
4. Outline consumer buying behaviour using any consumer decision-making model. Illustrate how organizations use these insights for strategy.

Course Outcome 2 (CO2):

1. Define MTBF and MTTR.
2. What is a series system in reliability?
3. A system has two components in series with reliabilities 0.95 and 0.9. Compute system reliability. Explain MTBF, MTTR, and availability with suitable examples.
4. Explain FMEA and FTA with steps, structure, and an industrial case example.

Course Outcome 3 (CO3):

1. Define CMMS and mention two of its benefits.
2. Write short notes on two-bin system.
3. Explain the process of maintenance planning and scheduling. Develop a PM schedule for any mechanical equipment.
4. Discuss ABC, VED, and two-bin systems. Prepare a spare parts classification for a sample inventory of 10 items.

Course Outcome 4 (CO4):

1. What is the bathtub curve?
2. Define shape and scale parameters in Weibull distribution.
3. Explain the bathtub curve in detail. Describe each of its three phases with industrial relevance.
4. Fit a Weibull distribution to given failure data (create any sample data). Explain parameter estimation and probability plotting.

Course Outcome 5 (CO5)

1. What is Lock-out/Tag-out (LOTO)?
2. Explain TPM and its eight pillars. Calculate OEE for a machine with assumed data and interpret results.
3. Describe the complete RCM process with decision diagrams. Explain how RCM improves reliability and safety.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SIXTH SEMESTER B TECH DEGREE EXAMINATION, MAY 2027

Course Code: **B24ME3P21**

Course Name: **MAINTENANCE MANAGEMENT AND RELIABILITY ENGINEERING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the objectives of maintenance and how they help improve equipment availability in industries.
2. Differentiate between preventive maintenance and predictive maintenance with suitable industrial examples.
3. Define reliability, availability, and maintainability (RAM). Explain their interrelationship.
4. A system has a failure rate of 0.002 failures/hour. Calculate MTBF. Explain its significance.
5. What are the steps involved in preparing a preventive maintenance (PM) schedule?
6. Explain ABC analysis and how it helps in spare parts inventory management.
7. Describe the three regions of the bathtub curve and their industrial relevance.
8. Define the shape (β) and scale (η) parameters of the Weibull distribution and explain their significance in failure modelling.
9. What is Overall Equipment Effectiveness (OEE)? Mention its three components.
10. Explain the purpose of Lock-out/Tag-out (LOTO) procedures in maintenance activities.

PART B

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

Module 1

11. Discuss the different types of maintenance: breakdown, preventive, predictive, reliability centered maintenance, and TPM. Explain their advantages, limitations, and suitability for mechanical equipment with relevant examples. (14 marks)

OR

12. Explain the objectives and functions of maintenance management in modern industries. Illustrate how effective maintenance policies improve equipment availability, productivity, and safety. Provide mechanical engineering–related applications. (14 marks)

Module 2

13. A mechanical system contains three components in series, with reliabilities 0.92, 0.95, and 0.90.
    a. Compute system reliability.
    b. Suggest a redundancy method to improve reliability and re-compute reliability if the third component has a parallel standby unit with reliability 0.90.
    c. Explain the industrial significance of series–parallel configuration choices. (14 marks)

OR

14. Define and explain MTBF, MTTR, availability, failure rate, and reliability function R(t). A pump has a constant failure rate of 0.0015 failures/hour and an average repair time of 3 hours.
    a. Compute MTBF and availability.
    b. Plot and interpret the reliability function over 500 hours.
    c. Discuss how RAM analysis helps in maintenance decision-making. (14 marks)

Module 3

15. Explain the complete procedure for preparing a Preventive Maintenance (PM) program for a machining workshop. Include planning steps, scheduling tools (Gantt, priority systems), manpower allocation, documentation, and feedback mechanisms. (14 marks)

OR

16. What is a CMMS? Describe its architecture, functions, reports, and practical benefits in maintenance management. Explain how CMMS integrates with spare management, failure data, and maintenance scheduling using examples. (14 marks)

Module 4

17. Explain the bathtub curve and describe the characteristics of the early-failure, constant-failure, and wear-out periods. Using suitable examples, discuss how maintenance strategies differ for each region. (14 marks)

OR

18. A dataset of failure times for a ball-bearing shows Weibull parameters $\beta = 1.8$ and $\eta = 1800$ hours.
    a) Interpret the meaning of β and η.
    b) Compute reliability at 1000 hours and 2000 hours.
    c) Explain how Weibull probability plots help identify failure behaviour.
    d) Discuss how Weibull modelling supports preventive maintenance planning.

(14 marks)

Module 5

19. Explain the pillars of Total Productive Maintenance (TPM) and discuss how TPM improves Overall Equipment Effectiveness (OEE). Using a hypothetical machine dataset, show how OEE is calculated and interpreted. (14 marks)

OR

20. Describe the complete Reliability-Centered Maintenance (RCM) process including system selection, functional failure analysis, FMEA, decision logic, task selection, and implementation. Explain how RCM improves reliability and cost-effectiveness with mechanical engineering examples. (14 marks)

B24ME3P22	FINANCIAL ENGINEERING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course equips engineering students with essential financial concepts and quantitative tools required for effective decision-making in engineering projects and systems. The course emphasizes time value of money, project evaluation, risk and return analysis, valuation principles, and emerging financial technologies relevant to engineering practice. By integrating financial reasoning with engineering applications, the course enables students to understand cost implications, evaluate alternatives, and support sustainable and technology-driven engineering solutions.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the fundamentals of financial engineering and the importance of financial decision-making in engineering projects. (Cognitive Knowledge Level: Understand)
CO 2	Apply time value of money and basic risk–return concepts to evaluate engineering investment alternatives. (Cognitive Knowledge Level: Apply)
CO 3	Describe financial instruments and derivative concepts used for risk management in engineering and project environments. (Cognitive Knowledge Level: Understand)
CO 4	Apply quantitative tools and basic financial statement analysis to support engineering project evaluation and decision-making. (Cognitive Knowledge Level: Apply)
CO 5	Apply valuation concepts, cost of capital, and emerging FinTech tools to analyze engineering projects and systems. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	20	20	20
Understand	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Basics of Financial Engineering (7 Hours)

Introduction to financial engineering – Role in engineering projects and systems, importance of financial decision-making in engineering, types of financial markets – money market, capital market, basic financial terms – assets, liabilities, equity, interest, time value of money – simple and compound interest, concept of risk and return, introduction to engineering financial decision-making.

Module 2: Financial Instruments, Derivatives & Markets (7 Hours)

Investment instruments for engineering projects – shares, bonds, project financing instruments, primary vs. secondary markets, basics of exchanges relevant to projects, derivatives for risk management – forwards, futures, put and call options, margin requirements and settlement mechanisms, practical examples of financial products – loans, insurance, deposits, project cost hedging.

Module 3: Quantitative Tools & Financial Statement Analysis (7 Hours)

Financial statements for engineering projects – balance sheet, profit and loss (income) statement, simple financial ratio analysis – liquidity, profitability, solvency, quantitative tools for project evaluation – charts, tables, basic spreadsheet modeling, data interpretation for engineering decisions, cost-benefit and risk analysis of projects.

Module 4: Pricing & Valuation Concepts (7 Hours)

Valuation of engineering and project assets – present value, future value, bond valuation, stock valuation using dividend approach (conceptual), introduction to option pricing, understanding cost of capital, portfolio approach to evaluating multiple engineering projects, project prioritization using financial metrics.

Module 5: Applications of Financial Engineering & FinTech (8 Hours)

Practical applications of financial engineering in engineering projects, simple hedging examples, algorithmic and automated analysis of project finance, introduction to blockchain and digital finance for projects, technology in finance – online banking, UPI, digital wallets, financial risk management in engineering practice, case studies from manufacturing, energy, automation, and infrastructure projects.

Text Books

1. Prasanna Chandra, *Financial Management: Theory and Practice*, Tata McGraw-Hill Education, New Delhi.
2. Pandey I.M., *Financial Management*, Vikas Publishing House, New Delhi.
3. Kuchhal S. C., *Financial Management – An Analytical and Conceptual Approach*, Vikas Publishing House, New Delhi.

Reference Books

1. John J. Hampton, *Financial Decision Making*, Prentice Hall of India, New Delhi.

2. Ross, Westerfield, and Jordan, *Fundamentals of Corporate Finance*, McGraw-Hill Education, International Edition.
3. Hull, J. C., *Options, Futures, and Other Derivatives*, Pearson Education, International Edition.
4. Brealey, Myers, and Allen, *Principles of Corporate Finance,* McGraw-Hill Education.
5. Avadhani V. A., *Investment Management*, Himalaya Publishing House, Mumbai.
6. Narayanaswamy R., *Financial Accounting: A Managerial Perspective*, PHI Learning, New Delhi.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
Module 1		**7**
1.1	Introduction to financial engineering, role of finance in engineering decisions	2
1.2	Financial markets and basic financial terminology	3
1.3	Time value of money, risk–return concepts, basic financial decision-making	2
Module 2		**7**
2.1	Financial instruments – shares, bonds, mutual funds	3
2.2	Primary and secondary markets, stock exchanges	2
2.3	Derivatives – forwards, futures, options, margin and settlement basics	2
Module 3		**7**
3.1	Financial statements – balance sheet and income statement	3
3.2	Financial ratios and interpretation	2
3.3	Spreadsheet tools and basic data visualization for financial analysis	2
Module 4		**7**
4.1	Valuation concepts, present and future value	2
4.2	Bond and stock valuation fundamentals	1
4.3	Cost of capital, portfolio diversification, introduction to option valuation	2
Module 5		**8**
5.1	Applications of financial engineering and hedging concepts	2
5.2	Risk management fundamentals and real-life scenarios	2
5.3	FinTech ecosystem – digital payments, UPI, online banking	2
5.4	Blockchain basics, algorithmic trading overview, emerging trends	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Define financial engineering and state its importance for engineers.
2. Explain the concept of time value of money.
3. Define time value of money and state its importance in engineering decisions.

Course Outcome 2 (CO2):

1. Differentiate between primary and secondary markets.
2. What is a futures contract? State one application.

Course Outcome 3 (CO3):

1. List any three financial ratios and their purpose.
2. State the uses of spreadsheets in financial analysis.

Course Outcome 4 (CO4):

1. Define present value and future value.
2. What is meant by portfolio diversification?

Course Outcome 5 (CO5)

1. What is hedging? Give one real-life example.
2. State two applications of blockchain in finance.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SIXTH SEMESTER B TECH DEGREE EXAMINATION, MAY 2027

Course Code: **B24ME3P22**

Course Name: **FINANCIAL ENGINEERING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Explain the concept of time value of money.
2 Define time value of money and state its importance in engineering decisions.
3 Differentiate between primary and secondary markets.
4 What is a futures contract? State one application.
5 List any three financial ratios and their purpose.
6 State any three uses of financial ratios in decision-making.
7 What is meant by portfolio diversification?
8 Define present value and future value.
9 What is hedging? Give one real-life example.
10 State two applications of blockchain in finance.

PART B

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

Module 1

11 a. Explain financial markets and their role in economic development. (5 marks)

b. Discuss risk and return concepts with suitable examples. (9 marks)

OR

12 a. Explain risk and return with suitable examples. (5 marks)

b. An engineer has two investment options: Option A: Expected return 8% with low risk. Option B: Expected return 12% with high risk. Discuss the choice using risk–

return trade-off. (9 marks)

Module 2

13 a. Explain shares, bonds, and mutual funds. (5 marks)

b. Describe the working of futures and options markets with examples. (9 marks)

OR

14 a. Explain call and put options. (5 marks)

b. Discuss margin requirements and settlement mechanisms in futures trading. (9 marks)

Module 3

15 a. Explain the structure of a balance sheet. (5marks)

b. From the following data, calculate, Current Ratio and Net Profit Ratio
Current Assets = ₹2,00,000
Current Liabilities = ₹1,00,000
Net Profit = ₹40,000
Sales = ₹4,00,000 (9 marks)

OR

16 a. Explain the income statement and its components. (5 marks)

b. Describe how spreadsheets aid financial analysis and decision-making. (9 marks)

Module 4

17 a. Explain present value and future value concepts. (5 marks)

b. Calculate the present value of ₹10,000 receivable after 2 years at a discount rate of 10% per annum. (9 marks)

OR

18 a. Explain portfolio diversification. (5marks)

b. A bond pays annual interest of ₹90 and has a face value of ₹1,000. If the required rate of return is 9%, comment on whether the bond is fairly priced. (9 marks)

Module 5

19 a. Explain the concept of risk management in financial engineering. (5 marks)

b. Discuss simple hedging strategies used by businesses with real-world examples. (9 marks)

OR

20 a. Explain the role of FinTech in modern financial systems. (5 marks)

b. Discuss the applications of blockchain technology and digital payment systems in India. (9 marks)

B24ME3P23	TECHNOLOGY MANAGEMENT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Technology Management is essential for engineering graduates to understand how technology evolves, how organizations acquire and manage it, and how innovation contributes to competitiveness. This course introduces the principles of technology development, diffusion, forecasting, R&D management, strategic technological decision-making, and the human and environmental implications of technological change. Mechanical engineering students will gain the ability to evaluate technological alternatives, support innovation, apply technology policies, and contribute to sustainable and responsible technology deployment in industries. The course builds foundational skills needed to navigate a rapidly evolving technological environment, including digital transformation, emerging technologies, IP management, and green technology practices.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the fundamentals of technology management, types of technology, and the role of technological innovation in industrial competitiveness. (Cognitive Knowledge Level: Understand)
CO 2	Apply technology acquisition and forecasting methods to evaluate technological alternatives and emerging technology trends. (Cognitive Knowledge Level: Apply)
CO 3	Describe technology strategies, adoption mechanisms, and policy frameworks with reference to Indian and global contexts. (Cognitive Knowledge Level: Understand)
CO 4	Relate R&D processes, innovation frameworks, and intellectual property mechanisms in supporting industrial technology development. (Cognitive Knowledge Level: Understand)
CO 5	Explain human, environmental, and sustainability aspects influencing responsible technology deployment and management. (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	1	2	1	1	2	1	2	2
CO 2	3	3	2	3	2	1	2	2	1	2	3
CO 3	2	2	1	2	2	1	2	2	1	3	2
CO 4	3	3	2	2	3	1	1	2	2	3	3
CO 5	2	1	1	1	2	3	3	3	2	3	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Foundations of Technology Management (6 hours)

Foundations of technology management – technology evolution and growth – concepts and definitions of technology management – role and significance of technology in industry – impact of technology on society and business – technology and competition – organizing technology at the enterprise level – key issues in managing technological innovation – forms of technology: process technology, product technology – digital transformation fundamentals – strategic alignment of digital technologies with business goals.

Module 2: Technology Acquisition and Foresight (7 hours)

Technology acquisition – new technology development – alternatives for acquiring new technologies – management of acquired technology – technology forecasting: characteristics, principles, and process – need and role of technology forecasting – forecasting methods and techniques – planning and forecasting applications – technology generation and development processes – importance of technology development – emerging technologies landscape – horizon scanning and identification of disruptive technologies.

Module 3: Technology Strategy, Adoption, and Policy (8 hours)

Technology strategy: need, purpose, and key elements – technology adoption, diffusion, and absorption – competitiveness and productivity impacts – benefits and constraints in technology absorption – technology package and technological dependence – Indian experience in technology absorption and related issues – government initiatives and science & technology policy in India – sustainability considerations in technology decisions – responsible innovation practices – global technology policy trends – adaptation strategies for Indian industries.

Module 4: Managing R&D and Innovation (8 hours)

Role and importance of R&D in industry – corporate research and product lifecycle – R&D and production cost relationships – translation of R&D outputs into technology – innovation concepts and types – distinction between innovation and invention – frameworks for innovation management – organizational characteristics supporting innovation – intellectual property rights: trademarks, copyrights, patents, infringement and remedies – technology transfer and its role in new product development – role of government in innovation – globalization and innovation challenges – case studies on R&D and innovation management – agile and adaptive innovation management approaches.

Module 5: Human and Environmental Aspects (7 hours)

People and technology integration – human factors in technology management – organizational and psychological factors – technology and organizational structure – implications of technological change – automation and rationalization in the Indian context – HRM issues in R&D and innovation teams – technology assessment – environmental impact analysis – circular economy principles – green technology management – social responsibility considerations in technology deployment.

Textbooks

1. Tarek Khalil, *Management of Technology: The Key to Competitiveness*, McGraw-Hill
2. V. K. Narayanan, *Managing Technology and Innovation for Competitive Advantage*, Pearson
3. Pradip N. Khandwalla, *Fourth Eye: Excellence Through Creativity*, Wheeler Publishing

References

1. Frederick Betz, *Managing Technological Innovation: Competitive Advantage from Change*, Wiley
2. Joseph Schumpeter, *Capitalism, Socialism and Democracy (Innovation & Creative Destruction Concepts)* Routledge.
3. R. G. Desai, *Technology and Society*, Himalaya Publishing House.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**6**
1.1	Evolution of technology, definitions, scope	2
1.2	Role of technology in business, forms of technology	2
1.3	Technology innovation, digital transformation, strategic alignment	2
	Module 2	**7**
2.1	Technology acquisition concepts, alternatives	2
2.2	Management of acquired technology	2
2.3	Technology forecasting principles, need, applications	2
2.4	Forecasting techniques, horizon scanning, emerging tech	1
	Module 3	**8**
3.1	Technology strategy need and elements	2
3.2	Adoption, diffusion, absorption processes	2
3.3	Technology packages, technological dependence	2
3.4	Indian technology policies, global tech policies	2
	Module 4	**8**
4.1	Role of R&D, product lifecycle, innovation types	2
4.2	Innovation frameworks and organizational factors	2
4.3	IPR—patents, trademarks, copyrights, infringement	2
4.4	Technology transfer, government role, case studies	1
4.5	Agile and adaptive innovation approaches	1
	Module 5	**7**
5.1	Human factors, organizational implications	2
5.2	Technological change, automation in India	2
5.3	HR issues in R&D and innovation teams	1
5.4	Environmental impact, technology assessment	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Define technology management and state its importance.
2. Differentiate between product technology and process technology.
3. Explain the evolution of technology and discuss how technological innovation influences business competitiveness.
4. Describe the various forms of technology and analyse their relevance in mechanical engineering industries.

Course Outcome 2 (CO2):

1. What is horizon scanning in technology forecasting?
2. State any three methods used for acquiring new technology.
3. Discuss the process of technology acquisition. Compare different acquisition alternatives with examples.
4. Explain technology forecasting in detail. Describe qualitative and quantitative forecasting techniques used in industry.

Course Outcome 3 (CO3):

1. What is technology diffusion? Explain briefly.
2. List the key elements of a technology strategy.
3. Describe technology adoption, diffusion, and absorption with suitable industrial illustrations.
4. Discuss Indian technology policy and compare it with global technology policy trends.

Course Outcome 4 (CO4):

1. Differentiate between innovation and invention.
2. What is the role of patents in innovation management?
3. Explain the stages of R&D management and how organizations translate R&D outcomes into technological innovations.
4. Discuss IPR in detail—patents, trademarks, copyrights—and explain their role in protecting innovation.

Course Outcome 5 (CO5)

1. What is technology assessment?
2. State any two environmental impacts of technology deployment.
3. What are the key human factors affecting technology management? Explain their significance in industrial settings.
4. Explain environmental impact analysis and discuss green technology management principles with examples.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SIXTH SEMESTER B TECH DEGREE EXAMINATION, MAY 2027

Course Code: **B24ME3P23**

Course Name: **TECHNOLOGY MANAGEMENT**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define technology management and explain its relevance in modern industrial operations.
2. Distinguish between product technology and process technology with suitable examples.
3. What is technology acquisition? Mention any two alternatives for acquiring new technology.
4. Define technology forecasting. State any two forecasting techniques.
5. What is technology diffusion? Explain its industrial significance.
6. List the key elements of a technology strategy.
7. Differentiate between innovation and invention.
8. What is a patent? State any two advantages of patent protection in R&D.
9. What is technology assessment? Mention its purpose.
10. State any two environmental impacts of technology deployment.

PART B

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

Module 1

11. Explain the evolution of technology and discuss how technological innovation enhances industrial competitiveness. Provide examples from mechanical engineering industries. (14 marks)

OR

12. Discuss the various forms of technology—product, process, and digital technologies and analyze their role in shaping business performance in modern industries. (14 marks)

Module 2

13. Describe the complete process of technology acquisition. Compare different acquisition alternatives and explain how organizations evaluate the suitability of a new technology. (14 marks)

OR

14. Explain the principles, need, and applications of technology forecasting. Discuss at least three forecasting methods and evaluate their suitability in emerging technology planning. (14 marks)

Module 3

15. Explain technology adoption, diffusion, and absorption with suitable industry examples. Discuss the benefits and constraints involved in each process. (14 marks)

OR

16. Describe India's science and technology policies and compare them with major global technology policy trends. Discuss adaptation strategies suitable for Indian industries. (14 marks)

Module 4

17. Explain the stages of R&D management and discuss how R&D outputs are translated into technological innovations. Use suitable industrial examples. (14 marks)

OR

18. Discuss in detail the major intellectual property rights (patents, copyrights, trademarks) and analyze their importance in protecting and commercializing innovation. (14 marks)

Module 5

19. Discuss the human factors influencing technology management. Explain the organizational and psychological factors that affect the success of technology adoption. (14 marks)

OR

20. Explain the need for environmental impact analysis in technology management. Discuss circular economy principles and green technology practices with examples. (14 marks)

B24ME3P24	INDUSTRY 4.0 AND INTERNET OF THINGS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Industry 4.0 and the Internet of Things (IoT) are transforming modern manufacturing by connecting machines, enabling real-time data monitoring, and improving productivity through smart technologies. This course introduces mechanical engineering students to the fundamental concepts of Industry 4.0, IoT devices, sensors, data, automation, and intelligent systems. It provides an elementary understanding of how these technologies enhance machine performance, support predictive maintenance, and enable smarter, safer, and more efficient industrial operations.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the evolution, concepts, and basic technologies of Industry 4.0 and identify their relevance to mechanical engineering (Cognitive Knowledge Level: Understand).
CO 2	Outline the fundamentals of IoT, including sensors, microcontrollers, and communication technologies used in mechanical systems. (Cognitive Knowledge Level: Understand)
CO 3	Explain how IoT is applied in machines, manufacturing, predictive maintenance, and simple cyber-physical systems. (Cognitive Knowledge Level: Understand)
CO 4	Interpret basic concepts of data analytics, AI/ML, cloud platforms, and cybersecurity in Industry 4.0 environments. (Cognitive Knowledge Level: Understand)
CO 5	Identify real-world applications, trends, sustainability aspects, and future technologies of Industry 4.0 and IoT. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	40	30
Understand	60	60	50
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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1 – Introduction to Industry 4.0 (7 Hours)

Concept of Industry 4.0., basic idea and history- Differences between Industry 1.0, 2.0, 3.0, and 4.0 - Key technologies: automation, robots, IoT, big data, artificial intelligence, machine learning - Smart factory: simple explanation and benefits - Applications in mechanical engineering: CNC integration, automated machining, condition monitoring - Benefits and challenges of Industry 4.0 in industries.

Module 2 – Basics of IoT (7 Hours)

IoT: definition, evolution- Real-life examples (home, cars, machines) - Basic IoT structure: sensors, microcontroller, communication, cloud- Common sensors used in mechanical engineering (temperature, pressure, vibration) - Introduction to microcontrollers (Arduino, ESP32) - Simple communication methods: Wi-Fi, Bluetooth- Basic idea of edge computing and cloud storage.

Module 3 – IoT in Machines and Manufacturing (7 Hours)

IoT in machines: measuring temperature, pressure, vibration - Machine-to-Machine (M2M) communication in simple terms - Basics of SCADA and PLC (non-mathematical introduction) - Predictive maintenance: why machines fail and how IoT helps - Examples: vibration monitoring of motors, temperature monitoring of bearings - Introduction to digital twins using simple mechanical examples.

Module 4 – Data, AI and Cloud in Industry 4.0 (7 Hours)

Why data is important in factories - Basics of data collection and dashboards - Very simple introduction to AI/ML (without algorithms) - How AI helps in mechanical engineering (fault detection, quality inspection) - Introduction to cloud platforms (AWS, Azure, Google Cloud) - Basic cybersecurity ideas: passwords, encryption, safe networks.

Module 5 – Applications, Trends, and Future Technologies (8 Hours)

IoT in mechanical engineering: HVAC, automobiles, production lines - Robots and cobots: simple explanation and uses - Basics of 3D printing and its role in Industry 4.0 - Smart logistics: AGVs, IoT-enabled warehouse management - Sustainability and energy-efficient manufacturing - Introduction to Industry 5.0 (human + robot teamwork) - Indian initiatives: Make in India, Digital India, Smart Manufacturing programs. Case Studies: Bosch's Industry 4.0 implementations, Siemens Amberg Electronics Plant, Reliance Jio's IoT platform etc.

Textbooks

1. Rajalakshmi & Shanmugalakshmi, *Introduction to IoT* – Wiley India
2. Alasdair Gilchrist, *Industry 4.0: The Industrial Internet of Things* – Apress
3. Sabrie Soloman, *Sensors Handbook* – McGraw Hill

Reference Books

1. Klaus Schwab, *The Fourth Industrial Revolution*
2. Jay Lee, *Industrial AI*
3. Government of India: *SAMARTH Udyog* documents

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Industrial revolutions; basics of Industry 4.0; key technologies	2
1.2	Smart factory; cyber-physical systems; benefits in mechanical engineering	2
1.3	Applications: machining, automation, condition monitoring	2
1.4	Opportunities, challenges; recap	1
	Module 2	**7**
2.1	What is IoT? Basic architecture and simple examples	2
2.2	Common sensors (temperature, pressure, vibration); microcontrollers	2
2.3	Basic communication: Wi-Fi, Bluetooth; data flow	2
2.4	Cloud basics; simple IoT demo discussion	1
	Module 3	**7**
3.1	IoT in machines; sensing vibration/temperature	2
3.2	M2M communication; introduction to PLC/SCADA	2
3.3	Predictive maintenance; mechanical condition monitoring	2
3.4	Basics of digital twins with simple examples	1
	Module 4	**7**
4.1	Importance of data in manufacturing; dashboards	2
4.2	Intro to AI/ML (no math): simple mechanical applications	2
4.3	Cloud platforms (AWS, Azure, Google IoT)	2
4.4	Cybersecurity basics; safe networks	1
	Module 5	**8**
5.1	IoT applications in HVAC, automotive, production lines	2
5.2	Robots & cobots; AGVs and smart logistics	2
5.3	Basics of 3D printing; sustainability in Industry 4.0	2
5.4	Industry 5.0; Indian programs: SAMARTH Udyog, Digital India	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. What is Industry 4.0? List any two of its key technologies.
2. Differentiate Industry 3.0 and Industry 4.0.
3. Explain the evolution of industrial revolutions and discuss how Industry 4.0 benefits mechanical engineering.
4. Discuss the core technologies of Industry 4.0 with relevant applications in manufacturing

Course Outcome 2 (CO2):

1. What is the role of sensors in IoT? Give examples.
2. Differentiate between Wi-Fi and Bluetooth.
3. Define microcontroller and give two examples used in IoT systems.
4. Discuss the different IoT communication technologies and their applications in mechanical engineering systems.

Course Outcome 3 (CO3):

1. What is predictive maintenance?
2. Give any two examples of condition monitoring using IoT.
3. Explain IoT-based predictive maintenance with examples from mechanical equipment.
4. Describe SCADA and PLC systems. Explain how they integrate with IoT for smart manufacturing.

Course Outcome 4 (CO4):

1. Why is data important in Industry 4.0?
2. What is AI? Give one application in mechanical engineering.
3. Explain how AI and machine learning support defect detection and predictive maintenance in manufacturing.
4. Describe cloud computing and cybersecurity needs in IoT-enabled manufacturing environments.

Course Outcome 5 (CO5)

1. What is a cobot?
2. State any two applications of IoT in automobiles.
3. What is Industry 5.0?
4. Discuss major real-world applications of Industry 4.0 and IoT in mechanical engineering.

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: **B24ME3P24**

Course Name: **INDUSTRY 4.0 AND INTERNET OF THINGS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Compare Industry 3.0 and Industry 4.0.
2. What is a smart factory? Give one simple example.
3. Differentiate between Wi-Fi and Bluetooth.
4. Define microcontroller and give two examples used in IoT systems.
5. Define SCADA.
6. Give any two examples of condition monitoring using IoT.
7. What is AI? Give one application in mechanical engineering.
8. Name any two cloud platforms used for IoT.
9. What is a cobot?
10. What is Industry 5.0?

PART B

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

Module 1

11. Explain the evolution of industrial revolutions and discuss how Industry 4.0 benefits mechanical engineering. (14 marks)

OR

12. Discuss the core technologies of Industry 4.0 with relevant applications in manufacturing. (14 marks)

Module 2

13. Explain the basic architecture of IoT with neat diagrams. Describe sensors, microcontrollers, and communication modules. (14 marks)

OR

14. Discuss the different IoT communication technologies and their applications in mechanical engineering systems. (14 marks)

Module 3

15. Explain IoT-based predictive maintenance with examples from mechanical equipment. (14 marks)

OR

16. Describe SCADA and PLC systems. Explain how they integrate with IoT for smart manufacturing. (14 marks)

Module 4

17. Explain how AI and machine learning support defect detection and predictive maintenance in manufacturing. (14 marks)

OR

18. Describe cloud computing and cybersecurity needs in IoT-enabled manufacturing environments. (14 marks)

Module 5

19. Discuss major real-world applications of Industry 4.0 and IoT in mechanical engineering. (14 marks)

OR

20. Explain sustainability, energy efficiency, and the future roadmap of Industry 4.0 with Indian initiatives. (14 marks)

B24ME3P25	DATA STRUCTURES AND ALGORITHMS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces fundamental data structures and classical algorithms essential for problem solving and efficient software development. Students learn how data is organized, stored, processed, and accessed using various structures such as arrays, stacks, queues, linked lists, trees, and graphs. Algorithm analysis (Big-O notation), recursion, searching, sorting, hashing, and graph algorithms are emphasized. Implementations and demonstrations are carried out using a suitable programming language, enabling learners to understand memory management, pointers, and object-oriented structuring of data structures. The course prepares students to model engineering problems computationally and develop efficient, modular, and scalable algorithmic solutions.

Prerequisites

Fundamental Programming Skills in C/C++

Course Outcomes

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

CO 1	Explain fundamental data structures, algorithmic paradigms, and asymptotic analysis. (Cognitive Knowledge Level: Understand)
CO 2	Apply linear data structures such as arrays, stacks, and queues for computational problem solving. (Cognitive Knowledge Level: Apply)
CO 3	Experiment with different types of linked lists and use them in engineering applications. (Cognitive Knowledge Level: Apply)
CO 4	Apply non-linear data structures (trees and graphs) to solve real-world problems. (Cognitive Knowledge Level: Apply)
CO 5	Make use of appropriate searching, sorting, and hashing methods for efficient data management. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	3	3	2	2	1					1	
CO 2	3	2	2	1	2					1	
CO 3	3	3	2	1	2					1	
CO 4	3	3	2	2	2					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	40	10	10
Understand	40	30	30
Apply	20	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Fundamentals of Data Structures and Algorithm Analysis (8 hours)

Data types: primitive and non-primitive; Abstract Data Types (ADT). Structure of algorithms: flowcharts and pseudocode. Algorithm efficiency: time & space complexity, Big-O, Ω, Θ notations. Growth of functions. Recursion basics; solving simple recurrences; Master theorem (concept). Algorithmic paradigms: brute force, divide and conquer, greedy, dynamic programming – overview.

Module 2: Linear Data Structures – Arrays, Stacks, Queues (7 hours)

Arrays: representation, memory layout, 1D & 2D arrays, sparse matrices. Stacks: definition, operations (PUSH/POP), infix-postfix conversion and evaluation. Queues: simple queue, circular queue, priority queue. Implementation using arrays and linked lists. Applications: expressionn evaluation, buffer handling, task scheduling

Module 3: Linked Lists (6 hours)

Singly linked list: creation, traversal, insertion, deletion. Doubly linked list: operations and use-cases. Circular linked lists. Linked list-based implementation of stacks & queues. Applications in engineering logs, simulation data structures, event systems.

Module 4: Non-Linear Data Structures – Trees and Graphs (8 hours)

Trees: binary trees, binary search trees (BST), insertion, deletion, search. Tree traversals: preorder, inorder, postorder. Balanced trees: AVL, B-Trees – concept only. Graphs: Terminology, Representation (Matrix & List). Graph traversals: BFS, DFS. Applications: Minimum spanning trees (Prim's, Kruskal's), shortest path (Dijkstra).

Module 5: Searching, Sorting, and Hashing (7 hours)

Searching: linear search, binary search. Sorting: bubble, insertion, merge, quick, heap sort – comparisons. Hashing: hash functions, collision resolution (chaining, open addressing). File organization: sequential, indexed, direct access – overview.

Text Books

1. Reema Thareja, *Data Structures Using C,* Oxford University Press.
2. Sartaj Sahni, *Data Structures, Algorithms and Applications in C++,* McGraw-Hill Edn.
3. Mark Allen Weiss, *Data Structures and Algorithm Analysis in C++* Pearson Education.

Reference Books

1. Goodrich, Tamassia, Mount, *Data Structures and Algorithms in C++,* Wiley.
2. Thomas H. Cormen, Charles Leiserson, Ronald Rivest, Clifford Stein, *Introduction to Algorithms (CLRS),* MIT Press.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**8**
1.1	Data types – primitive & non-primitive; ADT	1
1.2	Flowcharts and pseudocode	1
1.3	Time & Space Complexity; Big-O, Ω, Θ	2
1.4	Recursion basics; solving recurrences; Master theorem	2
1.5	Algorithmic paradigms overview	2
	Module 2	**7**
2.1	Arrays & sparse matrices – 2	1
2.2	Stacks & operations; infix→postfix	2
2.3	Queues: simple, circular, priority	2
2.4	Implementations using arrays & linked lists	1
2.5	Applications of linear structures	1
	Module 3	**6**
3.1	Singly linked list operations	2
3.2	Doubly and circular linked lists	2
3.3	Stack/queue implementation using linked lists	1
3.4	Engineering applications	1
	Module 4	**8**
4.1	Binary trees & BST operations	2
4.2	Tree traversals	2
4.3	Balanced trees (AVL, B-trees)	1
4.4	Graph representation & terminology	1
4.5	BFS & DFS	1
4.6	MST (Prim/Kruskal), Dijkstra	1
	Module 5	**7**
5.1	Searching (linear, binary)	2
5.2	Sorting algorithms	3
5.3	Hashing & collision resolution	2
5.4	File organization	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Define an ADT. Give two examples.
2. Differentiate Big-O, Ω, and Θ with examples.
3. Explain divide-and-conquer with the merge sort idea.

Course Outcome 2 (CO2):

1. Write C++ code for stack PUSH/POP using arrays.
2. Convert an infix expression to postfix.
3. Explain circular queue with diagram.

Course Outcome 3 (CO3):

1. Write insertion and deletion code for a singly linked list.
2. Compare singly, doubly, circular lists.
3. Implement queue using linked list.

Course Outcome 4 (CO4):

1. Write inorder, preorder, postorder traversals.
2. Explain adjacency list vs adjacency matrix.
3. Explain BFS and DFS with example.

Course Outcome 5 (CO5):

1. Compare all sorting algorithms by time complexity.
2. Explain hashing and collision handling methods.
3. Differentiate indexed and direct file organization.

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: **B24ME3P25**

Course Name: **DATA STRUCTURES AND ALGORITHMS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Define primitive and non-primitive data types with examples.
2 What is an ADT? Give two real-world examples.
3 Define Big-O notation. Give two examples.
4 Explain recursion with a simple C++ example.
5 Explain PUSH and POP operations in a stack.
6 What is a circular queue? Where is it used?
7 What is a doubly linked list? Give one advantage.
8 Define BFS and DFS.
9 What is hashing? Give an example of a hash function.
10 What is binary search? Give its time complexity.

PART B

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

Module 1

11 a. Explain primitive and non-primitive data types with suitable examples. How do they influence memory representation in C++? (7 marks)

b. Draw the flowchart and write the pseudocode for finding the largest element in an array. (7 marks)

OR

12 a. Using suitable examples, explain the difference between Big O, Omega, and Theta notations. (7 marks)

b. Using the Master Theorem, determine the time complexity of the recurrence: $T(n) = 2T(n/2) + n$ (7 marks)

Module II

13 a. Explain how a sparse matrix is represented in memory. Construct the 3-tuple representation for the matrix. (7 marks)

b. Convert the following infix expression to postfix and show the evaluation using a stack: A + B * (C – D). (7 marks)

OR

14 a. Explain the working of a circular queue. Illustrate with a diagram how the front and rear pointers move during enqueue and dequeue operations. (7 marks)

b. Discuss two real-world applications of queues or stacks such as simulation queues, buffer management, or expression evaluation. (7 marks)

Module III

15 a. Draw a singly linked list of five nodes. Explain insertion at the beginning and deletion at the end with diagrams. (7 marks)

b. Explain the structure of a doubly linked list. Give one engineering application where it is more suitable than a singly linked list. (7 marks)

OR

16 a. What is a circular linked list? Illustrate traversal with a neat diagram. (7 marks)

b. Explain how a queue can be implemented using a linked list. Mention the advantages over array implementation. (7 marks)

Module IV

17 a. Construct a Binary Search Tree (BST) for the keys: 40, 20, 60, 10, 30, 50, 70. Write the inorder, preorder and postorder traversals. (7 marks)

b. Explain Breadth-First Search (BFS) with a diagrammatic example. (7 marks)

OR

18 a. Explain the concept of AVL trees and why balancing is required. Illustrate LL and RR rotations with diagrams. (7 marks)

b. With a suitable example, explain how Dijkstra’s shortest path algorithm finds the minimum distance from a source node. (7 marks)

Module V

19 a. Compare linear search and binary search in terms of algorithm steps and time complexity. Give an example list where binary search cannot be used. (7 marks)

b. Explain insertion sort with an example list. Show each pass clearly. (7 marks)

OR

20 a. Explain the concept of hash functions. Demonstrate chaining by inserting the keys: 10, 22, 31, 4, 15, 28 (7 marks)

b. Differentiate sequential, indexed, and direct file organization with suitable examples. (7 marks)

B24ME3P26	SYSTEM MODELING AND SIMULATION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course is designed to provide a comprehensive understanding of the fundamental principles of system modeling and simulation, which are essential for analyzing and solving complex problems in engineering and management domains. It offers a solid foundation in developing models for both discrete and continuous systems, supported by techniques such as random number generation, design of simulation experiments, and output analysis. The course also emphasizes practical applications through the simulation of queuing systems, inventory models, manufacturing operations, and service processes.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the fundamental concepts of system modeling and simulation, including system components, model types, and phases of a simulation study. (Cognitive Knowledge Level: Understand)
CO 2	Explain the techniques for generating pseudo-random numbers and describe the purpose and procedure of statistical tests such as the Chi-square test, frequency test, poker test, and autocorrelation test. (Cognitive Knowledge Level: Understand)
CO 3	Apply simulation experiment design procedures by performing model verification, validation, calibration, input validation, and using appropriate variance reduction techniques. (Cognitive Knowledge Level: Apply)
CO 4	Apply simulation techniques to analyze queuing and inventory systems for assessing system performance and supporting decision-making. (Cognitive Knowledge Level: Apply)
CO 5	Model and analyze real-world systems in manufacturing, services, and logistics using various simulation languages and tools. (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	1	1	1		1		1		1
CO 2	3	2		2	2		1		1		1
CO 3	2	3	2	3	2		1	1	1	1	2
CO 4	2	3	2	3	2	1	1	1	1	1	2
CO 5	1	2	2	2	3		1	1	1	1	2

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	10	10
Understand	60	30	30
Apply		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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Concepts of Simulation (6 hours)

Introduction, system and environment, components of a system – Continuous and discrete systems – Model of a system, types of models – Situations to use simulation and when not to use – Steps in simulation study, phases of simulation study – Advantages of simulation study, limitations of simulation techniques – Applications of simulation.

Module 2: Random Numbers (6 hours)

Properties of random numbers – Generation of pseudo-random numbers – Techniques for random number generation – Tests for random numbers, frequency test, uniformity test, Chi-square test – Tests for autocorrelation – Poker test.

Module 3: Design of Simulation Experiment and Output Analysis (8 hours)

Verification and validation of simulation models – Calibration and validation of models – Input validation – Design of simulation experiment – Length of simulation runs, replication of runs – Elimination of initial bias in simulation experiments – Variance reduction techniques (VRT) – Distributed simulation – Meta modeling – Regression analysis, scatter diagram, simple linear regression – Method of least squares – Standard error of estimate – Caution in using regression analysis – Multiple regression – Statistical significance of regression – Coefficient of correlation – ANOVA.

Module 4: Simulation of Queuing systems and inventory systems (8 hours)

Queuing systems: components of queuing system, stationary and time-dependent queues, transient and steady states of the system – Measures of performance – Costs of customer waiting time and idle capacity – Kendall's notation – Time flow mechanics – Examples of queuing systems.

Inventory systems: Classification of inventory systems – Inventory costs – Single-item constant demand inventory model – EOQ with constant lead time – EOQ with shortage – Need for simulation of inventory systems – Examples.

Module 5: Introduction to Simulation Languages and Simulation examples (8 hours)

Brief history of simulation software – Simulation using JAVA, GPSS, SSF, MATLAB – Introduction to simulation languages, Arena, Automod, Extend, Flexsim, QUEST, SIMUL8, WITNESS, ProModel.

Hands-on simulation exercises using selected simulation software/tools for real-life systems such as manufacturing systems, material handling systems, inventory management systems, queuing systems etc.

Text Books

1. Jerry Banks, John S Carson, Barry L Nelson, David M Nicol, Shahabudeeen P., *Discrete-Event System Simulation*, Pearson Education, Prentice Hall.
2. Hira D. S., *System Simulation,* S Chand & Company Ltd.
3. Sheldon M Ross, *Simulation*, Elsevier.
4. Averill M Law, *Simulation Modeling and Analysis*, McGraw Hill Education Pvt. Ltd.

Reference Books

1. Frank L Severance, *System modeling and Simulation*. John Wiley and Sons, Inc.
2. H James Harrington and Kerim Tumay, Simulation Modeling Methods, McGraw Hill Education (India) Pvt. Ltd.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**6**
1.1	Introduction, the system and environment, components of a system, Continuous and discrete systems.	2
1.2	Model of a system, Tyes of Models, Situations to use simulation and when not to use.	2
1.3	Steps in simulation study, Phases of simulation study, Advantages of simulation study, Limitations of simulation techniques, Applications.	2
	Module 2	**6**
2.1	Properties of random numbers, Generation of Pseudo-Random numbers.	2
2.2	Techniques for generation of Random numbers,	1
2.3	Tests for Random Numbers: Frequency Tests, Uniformity test, Chi-Square Test	2
2.4	Tests for Autocorrelation, Poker test.	1
	Module 3	**8**
3.1	Verification and Validation of Simulation models, Calibration and validation of Models, Input Validation,	2
3.2	Design of Simulation experiment, Length of simulation runs, replication of runs, Elimination of initial Bias in Simulation experiments, Variance reduction techniques (VRT)	2
3.3	Distributed simulation, Meta modeling, Regression analysis, Scatter diagram, Simple linear Regression, Method of Least squares, Standard Error of Estimate	2
3.4	Caution in using regression analysis, Multiple regression, Statistical significance of Regression, Coefficient of Correlation, ANOVA	2
	Module 4	**8**
4.1	***Queuing systems:*** The components, stationery and time dependent queues, Transient and steady states of the system, Measure of Performance, Costs of Customer waiting time and Idle capacity	2
4.2	Kendall's Notation, Time flow Mechanics, Examples	2
4.3	**Inventory Systems***:* Classification, Costs, Single item constant demand inventory model, EOQ with constant lead time, EOQ with shortage	2
4.4	Why simulation of Inventory systems, Examples.	2

	Module 5	**8**
5.1	Brief history of simulation software, Simulation in JAVA, GPSS, SSF, MATLAB etc,	2
5.2	Introduction to simulation languages such as Arena, Automod, Extend, Flexsim, QUEST, SIMUL8, WITNESS, ProModel etc.	2
5.3	Simulation examples: Simulation of Manufacturing and Material Handling systems, Inventory management systems, Counter service, Car wash station	2
5.4	Simulation examples: Maintenance and repair problem, Counter service, Capacity planning, Profit analysis, Computer systems etc.	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Define a system and explain its components with an example.
2. Differentiate between continuous and discrete simulation models and illustrate with suitable examples.
3. Describe the phases of a simulation study and analyze how each phase contributes to the accuracy of the final model.

Course Outcome 2 (CO2):

1. Explain Arithmetic Congruential Generator with example.
2. Describe the Chi-square test to evaluate the uniformity of a given set of random numbers and interpret the result.
3. Explain poker test and perform the test on a sample of random numbers and analyze whether the generator satisfies randomness properties.

Course Outcome 3 (CO3):

1. Explain the difference between verification and validation in simulation and evaluate why both are essential.
2. Describe how initial bias can be eliminated in the results of simulation experiments.
3. Describe Analysis of Variance and different types of ANOVA.

Course Outcome 4 (CO4):

1. Explain how the performance of a queuing system can be evaluated in terms of a number of response parameters.
2. Describe how EOQ changes when shortage is allowed compared to when it is not for a given inventory system with constant demand.
3. Simulate a car-wash queue for 10 customers and analyze the waiting time and server utilization.

Course Outcome 5 (CO5)

1. List any four simulation languages or software tools and explain their primary application areas.
2. Build a simple material handling system model using Arena or Flexsim and describe the key blocks/modules used.
3. Simulate a conveyor-based material handling system and compute the utilization of each workstation.

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: **B24ME3P26**

Course Name: **SYSTEM MODELING AND SIMULATION**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Define simulation and list any two advantages of simulation studies.

2 Differentiate between continuous systems and discrete systems.

3 State the properties of good random numbers.

4 What is the Chi-square test? Mention its significance in testing random numbers.

5 Define model verification and model validation.

6 What is variance reduction technique? State its purpose.

7 What is Kendall's notation? Explain its significance in queuing systems.

8 Define EOQ. What assumptions are made in the basic EOQ model?

9 List any three simulation software tools and mention one application of each.

10 What is meant by simulation of manufacturing systems?

PART B

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

Module 1

11 a. Explain the steps involved in a simulation study. (5 marks)

b. Discuss the advantages, limitations, and applications of simulation. (9 marks)

OR

12 a. Explain the components of a system with a suitable example. (5 marks)

b. Describe different types of simulation models and situations where simulation is and is not appropriate. (9 marks)

Module 2

13 Describe the frequency test, poker test, and autocorrelation test for testing random numbers. (14 marks)

OR

14 a. Explain the concept of uniformity in random numbers. (5 marks)

b. Describe the Chi-square test procedure used for testing the randomness of numbers. (9 marks)

Module 3

15 a. Explain the need for input validation in simulation models. (5 marks)

b. Design a simulation experiment by selecting appropriate run length, number of replications, and methods for eliminating initial bias. (9 marks)

OR

16 A simulation study of a production line is conducted to estimate average waiting time. Initial simulation results show high output variance.

a. Apply any one variance reduction technique to improve the accuracy of the performance estimate. (5 marks)

b. Use regression analysis and ANOVA to analyze the effect of arrival rate and service time on the system performance. (9 marks)

Module 4

17 a. Apply Kendall's notation to model a real-life queuing system and identify its performance measures. (5 marks)

b. Simulate a queuing system and analyze system performance in terms of waiting time, queue length, and server utilization. (9 marks)

OR

18 a. Apply the EOQ model with constant demand to determine optimal order quantity. (5 marks)

b. Simulate an inventory system with shortages and evaluate its impact on total inventory cost. (9 marks)

Module 5

19 a. Briefly explain any two simulation languages or tools. (5 marks)

b. Simulate and analyze a material handling or inventory management system to support capacity or profit-related decisions. (9 marks)

OR

20 a. List any four simulation languages or software tools and explain their primary application areas. (5 marks)

b. A material handling system in a factory consists of two conveyors and one inspection station. Items arrive every 3 minutes, and inspection time varies uniformly between 2 and 6 minutes. Simulate the system and analyze throughput, resource utilization, and bottlenecks to recommend system improvements. (9 marks)

B24ME3P27	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces the fundamental principles of Artificial Intelligence and Machine Learning with a focus on applications in mechanical engineering. Students will learn essential data analytics concepts, supervised and unsupervised learning methods, neural network fundamentals, and modern AI tools used in design, diagnosis, and automation. Emphasis is placed on developing practical ML models, interpreting engineering data, and applying AI techniques to solve real-world engineering problems.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the basic concepts of AI/ML and the fundamentals of data analytics. (Cognitive Knowledge Level: Understand)
CO 2	Build and analyse prediction and classification models for engineering applications. (Cognitive Knowledge Level: Analyse)
CO 3	Apply unsupervised learning methods for pattern discovery and feature extraction. (Cognitive Knowledge Level: Apply)
CO 4	Implement basic neural network models, including CNNs, for engineering applications. (Cognitive Knowledge Level: Apply)
CO 5	Analyze and integrate AI techniques into engineering applications for intelligent decision-making. (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	2	–	–	–	1	–	2
CO 2	2	3	2	3	3	–	–	–	1	1	2
CO 3	2	3	2	3	3	–	–	–	1	–	2
CO 4	2	2	3	3	3	–	–	1	1	1	2
CO 5	2	3	3	3	3	1	–	1	1	1	3

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	20	20	10
Understand	40	40	30
Apply	20	40	30
Analyse	20		30
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: AIML, and Data Analytics for Mechanical Engineering (7 hours)

Introduction to Artificial Intelligence (AI) and Machine Learning (ML); evolution of AI; Scientific Machine Learning (SciML); applications of AI/ML in mechanical engineering. Fundamentals of Data Analytics: types of data, features, labels; data preprocessing, cleaning, and scaling; data visualization. Machine Learning concepts: learning from data; training, validation, and testing. Types of learning: supervised, unsupervised, and reinforcement learning.

MODULE 2: Predictive Modeling and Classification in Mechanical Systems (7 hours)

Prediction and Classification problems. Regression: linear and logistic regression; evaluation metrics for regression models; overfitting and regularization. Classification: decision trees, k-Nearest Neighbour (k-NN); evaluation metrics—accuracy, precision, recall, F1-score. Prediction and classification problems in mechanical engineering.

MODULE 3: Unsupervised Learning and Pattern Analysis in Engineering Data (7 hours)

Association and clustering problems: concept, relevance, and applications in mechanical engineering. Association rule mining: Apriori, FP-Growth. Clustering algorithms: k-Means, hierarchical clustering. Dimensionality reduction: Principal Component Analysis (PCA) and feature extraction.

MODULE 4: Neural & Deep Learning Techniques for Mechanical Applications (7 hours)

Artificial Neural Networks (ANNs): fundamentals, perceptron model, activation functions. Introduction to deep learning; feed-forward neural networks; backpropagation. Image recognition techniques and feature extraction fundamentals. Working of Convolutional Neural Networks (CNN): convolutional layer, pooling, flattening. Use cases: image-based fault detection and thermal imaging.

MODULE 5: Generative AI and Intelligent Systems for Smart Manufacturing (8 hours)

Introduction to Generative AI; generative AI for design optimization. Natural Language Processing; Large Language Models. AI for energy systems and sustainability; Digital Twins; Edge AI and IoT in smart manufacturing.
Software foundations for AI & ML: integrated development environments (IDEs) for ML operations; data handling, manipulation and visualization packages. Python ecosystem for AI; basic ML libraries—NumPy, Pandas, Scikit-learn, TensorFlow, Keras, Matplotlib, Seaborn, PyTorch, SciPy, OpenCV, NLTK; concept of APIs. Development of ML model for engineering applications and deployment.

Text Books

1. Stuart J. Russell & Peter Norvig, *Artificial Intelligence: A Modern Approach*, Pearson Education.
2. Tom M. Mitchell, *Machine Learning*, 1st Edition, McGraw-Hill.
3. Ethem Alpaydin, *Introduction to Machine Learning*, MIT Press.

Reference Books

1. Jay Lee, Yoon Kyung Lee & Behrad Bagheri, *Industrial AI*, Springer.
2. Abhijit Pandey, *Artificial Intelligence for Engineers*, Wiley.
3. A. C. Capretz, *Machine Learning for Engineering and Applied Science*, Springer.
4. Ramanathan Subramanian, *Applied Machine Learning for Engineers*, CRC Press.
5. Lihui Wang, *Data Analytics for Intelligent Manufacturing Systems*, Springer.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Introduction to Artificial Intelligence (AI) and Machine Learning (ML); evolution of AI.	1
1.2	Scientific Machine Learning (SciML); applications of AI/ML in mechanical engineering	1
1.3	Fundamentals of Data Analytics: types of data, features, labels; data preprocessing, cleaning, and scaling; data visualization.	3
1.4	Machine Learning concepts: learning from data; training, validation, and testing.	1
1.5	Types of learning: supervised, unsupervised, and reinforcement learning.	1
	Module 2	**7**
2.1	Classification vs prediction problems.	1
2.2	Regression: linear and logistic regression	1
2.3	Evaluation metrics for regression models; overfitting and regularization.	1
2.4	Classification: decision trees	1
2.5	k-Nearest Neighbour (k-NN)	1
2.6	Evaluation metrics—accuracy, precision, recall, F1-score.	1
2.7	Prediction and classification problems in mechanical engineering.	1
	Module 3	**7**
3.1	Association and clustering problems: concept, relevance, and applications in mechanical engineering.	1
3.2	Association rule mining: Apriori algorithm	1
3.3	FP-Growth algorithm	1
3.4	Clustering algorithms: k-Means.	1
3.5	Hierarchical clustering	1
3.6	Dimensionality reduction: Principal Component Analysis (PCA) and feature extraction.	2

	Module 4	**7**
4.1	Artificial Neural Networks (ANNs): fundamentals, perceptron model, activation functions.	1
4.2	Introduction to deep learning; feed-forward neural networks; backpropagation.	2
4.3	Image recognition techniques and feature extraction fundamentals.	1
4.4	Working of Convolutional Neural Networks (CNN): convolutional layer, pooling, flattening.	2
4.5	Use cases: image-based fault detection and thermal imaging.	1
	Module 5	**8**
5.1	Introduction to Generative AI; generative AI for design optimization.	1
5.2	Natural Language Processing; Large Language Models.	1
5.3	AI for energy systems and sustainability, Digital Twins, Edge AI and IoT in smart manufacturing.	2
5.4	Software foundations for AI & ML: integrated development environments (IDEs) for ML operations; data handling, manipulation and visualization packages.	2
5.5	Python ecosystem for AI; basic ML libraries—NumPy, Pandas, Scikit-learn, TensorFlow, Keras, Matplotlib, Seaborn, PyTorch, SciPy, OpenCV, NLTK; concept of APIs.	1
5.6	Development of ML model for engineering applications and deployment.	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the differences between Artificial Intelligence, Machine Learning, and Deep Learning with suitable examples.
2. Describe the various types of data (structured, unstructured, categorical, numerical) used in data analytics.
3. Illustrate the steps involved in data preprocessing and explain why each step is important.
4. Summarize the key differences between supervised, unsupervised, and reinforcement learning.

Course Outcome 2 (CO2):

1. Evaluate the performance of a linear regression model using appropriate evaluation metrics.
2. Assess a classification model using accuracy, precision, recall, and F1-score.
3. Critique the issues of overfitting in regression models and suggest suitable regularization techniques.
4. Justify the selection of k-Nearest Neighbour (k-NN) for a mechanical engineering classification problem.

Course Outcome 3 (CO3):

1. Implement a perceptron model to classify a simple dataset and explain its working.
2. Demonstrate the role of activation functions in training neural networks.
3. Use a basic CNN architecture to perform feature extraction from an image.
4. Apply convolution and pooling operations on a sample image and interpret the changes.

Course Outcome 4 (CO4):

1. Apply the Apriori algorithm to generate association rules from a sample dataset.
2. Use the k-Means algorithm to cluster data points and interpret the obtained clusters.
3. Implement hierarchical clustering and compare it with k-Means.
4. Apply PCA to reduce dimensionality and interpret the significance of the principal components.

Course Outcome 5 (CO5)

1. Analyze how Digital Twins can be used for predictive maintenance in mechanical systems.
2. Examine the role of Edge AI in smart manufacturing and real-time decision-making.
3. Analyze the use of Generative AI for engineering design optimization.
4. Integrate suitable ML tools and libraries to develop and deploy an ML model for an engineering application.

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: **B24ME3P27**

Course Name: **ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Define supervised and unsupervised learning with one example each.

2 What is data preprocessing? Mention any two preprocessing steps.

3 What is the difference between linear regression and logistic regression?

4 List any two-evaluation metrics used for regression models.

5 What is clustering? Name any two clustering algorithms.

6 Define support and confidence in association rule mining.

7 What is the role of an activation function in a neural network?

8 What is pooling in a Convolutional Neural Network (CNN)?

9 What is a Digital Twin?

10 Name any two Python libraries commonly used in machine learning

PART B

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

Module 1

11 Explain the evolution of Artificial Intelligence and Machine Learning and discuss their applications in mechanical engineering with suitable examples. (14 marks)

OR

12 Describe the steps involved in data preprocessing. Explain the importance of data cleaning, scaling, and visualization in building ML models. (14 marks)

Module 2

13 Explain k-Nearest Neighbour (k-NN) algorithm. Discuss how metrics such as accuracy, precision, recall, and F1-score are used to evaluate them. (14 marks)

OR

14 Describe linear and logistic regression models. Compare their applications, assumptions, and evaluation metrics in detail. (14 marks)

Module 3

15 Explain association rule mining. Describe the working of the Apriori algorithm with an example. (14 marks)

OR

16 Discuss k-Means and hierarchical clustering methods. Compare their working principles, advantages, and limitations. (14 marks)

Module 4

17 Explain the architecture of an Artificial Neural Network. Describe the perceptron model, activation functions, and the concept of backpropagation. (14 marks)

OR

18 Describe the structure and working of a Convolutional Neural Network (CNN). Explain convolution, pooling, and flattening operations with suitable illustrations. (14 marks)

Module 5

19 Discuss Digital Twins and Edge AI in the context of smart manufacturing. Explain how they enable intelligent decision-making in mechanical systems. (14 marks)

OR

20 Explain the steps involved in developing and deploying an ML model for an engineering application. (14 marks)

B24ME3P28	ALGORITHMS FOR NON-TRADITIONAL OPTIMIZATION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Optimization Techniques in Engineering introduces students to systematic approaches for identifying optimal solutions in complex engineering problems under given constraints. The course emphasizes the formulation of optimization problems, understanding of heuristic and metaheuristic methods, and their application to mechanical engineering systems. It provides in-depth exposure to non-traditional optimization algorithms such as Simulated Annealing, Genetic Algorithms, Particle Swarm Optimization, and multi-objective optimization techniques. Through theoretical foundations and engineering-oriented case studies, students develop the ability to model, analyze, and solve real-world engineering design, manufacturing, and scheduling problems. The course prepares learners for advanced studies and professional practice in computational optimization, design optimization, and intelligent engineering systems.

Prerequisites

Nil

Course Outcomes

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

CO 1	Apply optimization concepts to formulate engineering optimization problems by identifying objectives, constraints, decision variables, feasible regions, and performance criteria. (Cognitive Knowledge Level: Apply)
CO 2	Build Simulated Annealing algorithms to solve optimization problems in mechanical engineering systems. (Cognitive Knowledge Level: Apply)
CO 3	Apply Genetic Algorithms, including encoding, operators, and constraint handling techniques, to solve design, scheduling, and manufacturing optimization problems. (Cognitive Knowledge Level: Apply)
CO 4	Develop Particle Swarm Optimization techniques to obtain optimal solutions for engineering optimization problems. (Cognitive Knowledge Level: Apply)
CO 5	Make use of multi-objective optimization techniques to obtain and interpret Pareto-optimal solutions for multi-criteria engineering design problems. (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	–	–	–	–	–	–	–	–
CO 2	2	3	3	2	2	–	–	–	–	–	–
CO 3	2	3	3	2	2	–	–	–	–	–	–
CO 4	2	2	3	2	2	–	–	–	–	–	–
CO 5	2	2	3	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Fundamentals of Optimization in Engineering (6 hours)

Introduction to Optimization- Requirements for the application of Optimization methods-Classification of optimization problems: single vs multi-objective, constrained vs unconstrained, continuous vs discrete – Defining the system Boundaries, Performance Criterion, Independent variables-Constraints and feasible region –, System Model, Local and Global Optima, Application of Optimization in Engineering, Heuristics, P and NP, Evaluation of Heuristics. Introduction to Non-Traditional Algorithms.

Module 2: Simulated Annealing (8 hours)

Simulated Annealing- Introduction – The basic model – The annealing algorithm – Generic decisions, problem-specific decisions – Acceptance probability – Cooling schedules – Neighborhood structures – Sampling – Cost function – Aids to fine tuning – Enhancements and modifications – Parallel implementations (overview) – Engineering-oriented examples and benchmark problems – Applications in mechanical engineering.

Module 3: Genetic Algorithms and Evolutionary Optimization (8 hours)

Genetic Algorithm- Basics, Intrinsic parallelism and the schema theorem, Population related factors: Population size, Seeding, selection mechanisms, Fitness calculation, Modified operators, Multi Point Crossover, Inversion, Dominance, Chromosome coding and representations: Binary vs Gray coding, Non-Binary coding, sequence representation-Constraint handling techniques: penalty methods, repair strategies (introductory) – Hybridization, Parallel implementations, Applications in design optimization, scheduling, and manufacturing systems.

Module 4: Particle Swarm Optimization Techniques (6 hours)

Particle Swarm Optimization- Introduction, Key concepts: Particle, Swarm, position, velocity, exploration and exploitation, Initialization, Evaluation, Memory, Global Best, Velocity update, position update, Iteration. Variants of PSO: inertia weight approach, constriction factor (introductory) – Comparison with GA and SA (conceptual) – Applications in engineering optimization.

Module 5: Multi-Objective Optimization and Advanced Applications (8 hours)

Multi Objective Optimization- Introduction, Principles, Differences between single and multi-objective optimization – Pareto optimality and Pareto front concepts – Classical Methods weighted sum method, ε-constraint method, weighted metric method (any two)- Multiple objective Genetic Algorithm-NSGA- Advantages and disadvantages – Visualization of Pareto fronts – Simulation results – Applications in multi-criteria engineering design problems.

Text Books

1. Kalyanmoy Deb, *Multi-Objective Optimization using Evolutionary Algorithms*, John Wiley & Sons Ltd., ISBN: 9814-12-685-3.
2. Orient Longman, *Modern Heuristic Techniques for Combinatorial Problems*, Blackwell Scientific Publications.
3. A Ravindran, K M Ragsdell and G V Reklaitis, *Engineering Optimization*, John Wiley & Sons Ltd., ISBN: 81-265-0933-3.

4. N V S Rao, *Optimization methods for Engineers*, Prentice-Hall of India Pvt Ltd, ISBN-978-81-203-4744-1.
5. S. S. Rao, *Engineering Optimization: Theory and Practice*, 4th Edition, Wiley India.

Reference Books

1. David E Goldberg, *Genetic Algorithms in search, Optimization and Machine Learning*, Pearson Education, Inc, ISBN: 81-7758-829-X.
2. Kalyanamoy Deb, *Optimization for Engineering Design, Algorithms and Examples*, Prentice-Hall of India Pvt Ltd, ISBN-81-203-0943-X.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**6**
1.1	Introduction to Optimization: Requirements for the application of Optimization methods, Defining the system Boundaries, Performance Criterion, Independent variables.	2
1.2	System Model, Local and Global Optima.	1
1.3	Application of Optimization in Engineering, Heuristics, P and NP, Evaluation of Heuristics.	2
1.4	Introduction to Non-Traditional Algorithms.	1
	Module 2	**8**
2.1	Simulated Annealing: Introduction, The Basic model, The annealing algorithm.	2
2.2	Generic decisions, Problem specific decisions, Examples, Aids to fine tuning.	2
2.3	Enhancements and modifications, Acceptance probability, Cooling.	2
2.4	The neighborhoods, Sampling, The cost function, Parallel implementations, Applications.	2
	Module 3	**8**
3.1	Genetic Algorithm- Basics, Intrinsic parallelism and the schema theorem.	2
3.2	Population related factors: Population size, Seeding, selection mechanisms, Fitness calculation.	2
3.3	Modified operators, Multi Point Crossover, Inversion, Dominance, Chromosome coding and representations: Binary vs Gray coding.	2
3.4	Non-Binary coding, sequence representation, Hybridization, Parallel implementations, Applications.	2
	Module 4	**6**
4.1	Particle Swarm Optimization: Introduction, Key concepts.	2
4.2	Particle, Swarm, position, velocity, exploration and exploitation.	1
4.3	Initialization, Evaluation, Memory.	1
4.4	Global Best, Velocity update, position update, Iteration. Applications.	2

	Module 5	**8**
5.1	Multi Objective Optimization: Principles, Differences with single objective.	1
	Pareto optimality and Pareto front concepts.	1
5.2	Classical Methods: any two methods like Weighted sum, epsilon constraint, weighted metric, etc.	2
5.3	Multiple objective Genetic Algorithm-NSGA, Advantages and disadvantages, Simulation results.	2
5.4	Applications in multi-criteria engineering design problems.	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Differentiate between local optimum and global optimum.
2. What is meant by constrained optimization?
3. Explain the steps involved in formulating an engineering optimization problem.
4. Discuss classification of optimization problems with suitable examples.

Course Outcome 2 (CO2):

1. What is acceptance probability in Simulated Annealing?
2. What is the role of cooling schedule?
3. Explain the Simulated Annealing algorithm with a flowchart.
4. Discuss the role of acceptance probability and cooling schedule.

Course Outcome 3 (CO3):

1. What is schema theorem?
2. List different selection mechanisms in GA.
3. Explain the working principle of a Genetic Algorithm with operators.
4. Discuss chromosome representations and fitness evaluation.

Course Outcome 4 (CO4):

1. What is inertia weight in PSO?
2. State one advantage of PSO over GA.
3. Explain variants of PSO.
4. Compare PSO with GA and Simulated Annealing.

Course Outcome 5 (CO5)

1. What is the weighted sum method?
2. What is NSGA?
3. Explain principles of multi-objective optimization.
4. Describe classical methods for multi-objective optimization.

MODEL QUESTION PAPER

QP CODE: Pages: 2

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SIXTH SEMESTER B TECH DEGREE EXAMINATION, MAY 2027

Course Code: **B24ME3P28**

Course Name: **ALGORITHMS FOR NON-TRADITIONAL OPTIMIZATION**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Define optimization and state its significance in engineering applications.

2 Explain the difference between local optimum and global optimum with a suitable example.

3 Explain the basic idea of Simulated Annealing and its analogy with the physical annealing process.

4 Describe the role of acceptance probability and cooling schedule in Simulated Annealing.

5 Explain the basic working principle of a Genetic Algorithm.

6 Differentiate between binary coding and Gray coding used in Genetic Algorithms.

7 Explain the concepts of particle, swarm, and velocity in Particle Swarm Optimization.

8 Describe the terms global best and local best in Particle Swarm Optimization.

9 Define multi-objective optimization and Pareto optimality.

10 Explain the concept of Pareto front in multi-objective optimization.

PART B

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

Module 1

11 a. Define optimization and list main elements of an optimization problem. (5 marks)

b. A component weight is given by $W = 2x + 3y$ subject to $x + y \geq 6$, $x \geq 0$, $y \geq 0$. Formulate the optimization problem and state whether it is constrained or unconstrained. (9 marks)

OR

12 a. Explain local optimum and global optimum in simple terms. (5 marks)

b. Formulate an optimization problem for minimizing fuel consumption of a vehicle by identifying objective function, decision variables, and constraints. (9 marks)

Module 2

13 a. Explain the basic idea of Simulated Annealing. (5 marks)

b. For the cost function $f(x) = (x - 4)^2$ with temperature $T = 100$ and $\Delta f = 2$, calculate the acceptance probability and explain its meaning. (9 marks)

OR

14 a. Explain the purpose of a cooling schedule in Simulated Annealing. (5 marks)

b. Apply Simulated Annealing steps to minimize surface roughness in a simple machining operation. (9 marks)

Module 3

15 a. Explain the basic steps of a Genetic Algorithm. (5 marks)

b. Apply Genetic Algorithm operators (selection, crossover, mutation) to solve a simple design optimization problem. (9 marks)

OR

16 a. Explain binary coding and Gray coding used in Genetic Algorithms. (5 marks)

b. Explain with example how a constraint can be handled in a Genetic Algorithm. (9 marks)

Module 4

17 a. Explain the basic terms used in Particle Swarm Optimization. (5 marks)

b. A particle has position = 2, velocity = 1, personal best = 1.8, global best = 1.5. Calculate the new position after one iteration using PSO concept. (9 marks)

OR

18 a. Explain exploration and exploitation in PSO. (5 marks)

b. Explain how PSO is used to solve a simple engineering optimization problem. (9 marks)

Module 5

19 a. Define multi-objective optimization and Pareto optimal solution. (5 marks)

b. Explain Pareto optimal solutions for a design problem with objectives of minimum weight and maximum strength. (9 marks)

OR

20 a. Explain the weighted sum method. (5 marks)

b. Apply the weighted sum method to convert a two-objective engineering problem into a single-objective problem. (9 marks)

B24ME3G11	QUANTITATIVE TECHNIQUES FOR ENGINEERS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Quantitative Techniques for Engineers is an interdisciplinary course designed to equip engineering students with systematic and analytical tools for effective decision-making and optimization in complex engineering systems. The course introduces mathematical modeling, optimization techniques, operations research methods, and decision analysis tools essential for solving real-world engineering problems. Emphasis is placed on problem formulation, algorithmic solution methods, computational aspects, and interpretation of results using engineering examples and case illustrations. By integrating quantitative methods with real-world engineering scenarios, the course builds the competence required to design efficient solutions, support managerial decisions, and enhance productivity in industrial and service environments.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand and formulate optimization and decision-making problems in engineering systems. (Cognitive Knowledge Level: Understand)
CO 2	Model real-world engineering and management problems and solve them using various methods (Cognitive Knowledge Level: Apply)
CO 3	Develop and solve transportation and assignment models for optimal allocation of resources. (Cognitive Knowledge Level: Apply)
CO 4	Apply scheduling, sequencing, decision theory, and simulation techniques to model, analyze, and solve engineering decision-making problems. (Cognitive Knowledge Level: Apply)
CO 5	Analyze queuing systems and competitive decision-making scenarios using queuing theory and game theory concepts. (Cognitive Knowledge Level: Analyze)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	3	3	2	2	2	–	–	–	–	1	2
CO 2	3	3	2	2	2	–	–	–	–	1	2
CO 3	3	3	2	2	2	–	–	–	–	1	2
CO 4	3	3	3	2	2	–	–	–	–	1	3
CO 5	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			
Understand	40	30	30
Apply	60	40	40
Analyse		30	30
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Introduction to quantitative techniques and optimization (7 Hours)

Introduction to quantitative techniques and decision-making; elements of an optimization problem; linear and nonlinear systems; linear programming problems (LPP); mathematical formulation; graphical approach to LPP; solution space and its characteristics. Basics of multi-objective optimization; Pareto optimality; Pareto front; algorithmic approaches to optimization; cost of computation; local and global optima. Concepts of heuristic and metaheuristic methods; engineering examples and case illustrations.

Module 2: Operations Research (7 Hours)

Basics of operations research; simplex algorithm; Big-M method; duality concepts; primal–dual relationships; economic interpretation of duality. Integer programming (IP) and mixed integer linear programming (MILP) concepts and formulation. Formulation and solution of LPP, IP, and MILP models using optimization solvers.

Module 3: Transportation and Assignment Models (7 Hours)

Transportation problem: formulation; balanced and unbalanced transportation problems; methods for obtaining an initial feasible solution (North-West Corner, Least Cost, Vogels approximation); optimality test (Stepping stone method); degeneracy in transportation problems. Assignment problem: formulation; Hungarian method; variants including unbalanced problems and maximization cases; travelling salesman problem (TSP) through assignment reduction.

Module 4: Scheduling, Simulation and Decision Theory (7 Hours)

Scheduling and sequencing: basic concepts and objectives; types of scheduling problems; Johnson's algorithm for two- and three-machine flow shop problems; mathematical model for the n-job, two-machine sequencing problem. Decision theory; steps in the decision-theoretic approach; decision-making under conditions of certainty, risk, and uncertainty. Simulation; generation of random numbers; Monte Carlo simulation; applications.

Module 5: Queuing Systems & Game Theory (8 Hours)

Queuing Systems: basic structure of a queue; elements of a queuing system; Kendall's notation; operating characteristics; classification of queuing models; M/M/1 and M/M/c systems; applications of queuing systems in engineering and service systems. Game theory: terminology; two-person zero-sum games; pure strategy; saddle point; value of the game; mixed strategy; 2×2 matrix games; m×2 matrix games using graphical methods; reduction of game size using dominance and transformations; Nash equilibrium.

Textbooks

1. Panneerselvam R., *Operations Research,* EEE Edition PHI
2. Kanti Swarup P.K. Gupta & Man Mohan, *Operations Research*, S Chand & Sons.
3. Kapoor V.K., *Operations Research Concepts, Problems. & Solutions*, S Chand & Sons.

References

1. Hillier & Lieberman, *Introduction to Operations Research*, McGraw Hill.
2. H.A. Taha, *Operations Research: An Introduction*, Pearson Education.
3. Ravindran, Phillips & Solberg, *Operations Research: Principles and Practice*, Wiley.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
Module 1		**7**
1.1	Introduction to quantitative techniques and decision-making; elements of an optimization problem; linear and nonlinear systems.	1
1.2	Linear programming problems (LPP); mathematical formulation of optimization problems; graphical approach to LPP; solution space and its characteristics.	3
1.3	Basics of multi-objective optimization; Pareto optimality; Pareto front; algorithmic approaches to optimization; cost of computation; local and global optima.	2
1.4	Concepts of heuristic and metaheuristic methods; engineering examples and case illustrations.	1
Module 2		**7**
2.1	Simplex method, Big-M method	3
2.2	Duality concept and interpretation.	1
2.3	Integer programming (IP) and mixed integer linear programming (MILP) concepts and formulation.	1
2.4	Formulation and solution of LPP, IP, and MILP models using optimization solvers.	2
Module 3		**7**
3.1	Transportation model: Formulation, Methods for initial feasible solution: NWCM, LCM, Vogel's Approximation	2
3.2	Optimality test - degeneracy in transportation problems.	1
3.3	Assignment model: Formulation and Hungarian method, Problems	2
3.4	Variants including unbalanced problems and maximization cases;	1
3.5	Travelling salesman problem (TSP) through assignment reduction.	1
Module 4		**7**
4.1	Scheduling and sequencing: basic concepts and objectives; types of scheduling problems; Johnson's algorithm for two- and three-machine flow shop problems.	3
4.2	Mathematical model for the n-job, two-machine sequencing problem.	1
4.3	Decision theory; steps in the decision-theoretic approach; decision-making under conditions of certainty, risk, and uncertainty.	1
4.4	Simulation; generation of random numbers; Monte Carlo simulation; applications in engineering systems.	2
Module 5		**8**
5.1	*Queuing Theory:* Basics, elements of a queuing system, Kendall's notation- Operating characteristics and classification of models	1
5.2	M/M/1 and M/M/c systems, applications.	2

5.3	Nature, assumptions, and terminology of game theory- Two-person zero-sum games. Pure Strategy Games: Saddle point	1
5.4	Mixed Strategy Games: Games without saddle points, 2×2 matrix games (algebraic solution), m×2 matrix games (graphical method)	2
5.5	Reduction of game size using dominance and transformations	1
5.6	Nash Equilibrium	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Identify the role of quantitative techniques in engineering decision-making.
2. Formulate linear and nonlinear optimization problems from engineering situations.
3. Analyze solution space and its characteristics using graphical methods.
4. Explain multi-objective optimization concepts including Pareto optimality and Pareto front.
5. Evaluate algorithmic, heuristic, and metaheuristic approaches with respect to computational cost and optimality.

Course Outcome 2 (CO2):

1. Explain the fundamentals and scope of operations research in engineering systems.
2. Apply the simplex, Big-M, and two-phase methods to solve linear programming problems.
3. Analyze primal–dual relationships and interpret dual solutions economically.
4. Formulate integer programming and mixed integer linear programming models.
5. Solve LPP, IP, and MILP models using optimization solvers.

Course Outcome 3 (CO3):

1. Formulate transportation and assignment problems from practical data.
2. Obtain initial feasible solutions for transportation problems using standard methods.
3. Test optimality and handle special cases such as degeneracy and unbalanced problems.
4. Apply the Hungarian method to solve assignment problems efficiently.
5. Solve travelling salesman problems using assignment model reduction.

Course Outcome 4 (CO4):

1. Explain basic concepts and objectives of scheduling and sequencing problems.
2. Apply Johnson's algorithm to solve two- and three-machine sequencing problems.
3. Develop mathematical models for n-job, two-machine flow shop problems.
4. Analyze decision-making problems under conditions of risk and uncertainty.
5. Apply simulation and Monte Carlo methods for modeling engineering systems.

Course Outcome 5 (CO5)

1. Explain the structure and elements of queuing systems using Kendall's notation.
2. Analyze performance measures of M/M/1 and M/M/c queuing models.
3. Apply queuing theory concepts to real-life engineering and service systems.
4. Solve two-person zero-sum games using pure and mixed strategies.
5. Analyze competitive situations using dominance principles and Nash equilibrium.

MODEL QUESTION PAPER

QP CODE: Pages: 4

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SIXTH SEMESTER B TECH DEGREE EXAMINATION, MAY 2027

Course Code: **B24ME3G11**

Course Name: **QUANTITATIVE TECHNIQUES FOR ENGINEERS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain degeneracy and infeasibility.
2. What are the elements of an optimization problem?
3. What is the purpose of adding artificial variables in a simplex algorithm?
4. What is the economic interpretation of dual variables in linear programming?
5. Solve the following using N-W corner rule.

	M_1	M_2	M_3	M_4	
W_1	2	2	2	1	3
W_2	10	8	5	4	7
W_3	7	6	6	8	5
	4	3	4	4	

6. Discuss the similarity between transportation problem and assignment problem.
7. Explain any 2 objectives of scheduling.
8. Explain any one method of random number generation.
9. What is Kendall notation? Explain any one queuing model based on Kendall notation.
10. Reduce the following 2×3 zero-sum game using dominance rules and obtain the reduced payoff matrix. Check whether any row or column can be eliminated through dominance, and write the resulting simplified game matrix.

	B_1	B_2	B_3
A_1	4	7	6
A_2	5	6	8

PART B

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

Module 1

11. A company manufactures two products, *X* and *Y by* using three machines *A*, *B*, and *C*. Machine *A* has 4 hours of capacity available during the coming week. Similarly, the available capacity of machines *B* and *C* during the coming week is 24 hours and 35 hours respectively. One unit of product *X* requires one hour of Machine *A*, 3 hours of machine *B* and 10 hours of machine *C*. Similarly, one unit of product *Y* requires 1 hour, 8 hour and 7 hours of machine *A*, *B* and *C* respectively. When one unit of *X* is sold in the market, it yields a profit of Rs. 5/- per product and that of *Y* is Rs. 7/- per unit. Solve the problem by using graphical method to find the optimal product mix.

(14 marks)

OR

12. Describe single-objective and multi-objective optimization. Explain Pareto optimality and Pareto front with appropriate illustrations. (14 marks)

Module 2

13. Solve the following:

Maximize $Z = 4x_1 + 5x_2 - 3x_3$

Subject to

$x_1 + x_2 + x_3 = 10$

$x_1 - x_2 \geq 1$

$2x_1 + 3x_2 + x_3 \leq 30$

$x_1 \geq 0, x_2 \geq 0, x_3 \geq 0$ (14 marks)

OR

14. Explain the concept of duality in linear programming. Discuss primal–dual relationships and the economic interpretation of dual variables. (14 marks)

Module 3

15. Find the optimal solution for the following transportation problem.

	Market 1	Market 2	Market 3	Market 4	Market 5	Supply
Plant 1	10	2	16	14	10	300
Plant 2	6	18	12	13	16	500
Plant 3	8	4	14	12	10	825
Plant 4	14	22	20	8	18	375
Demand	350	400	250	150	400	

(14 marks)

OR

16. A marketing manager has 5 salesman and 5 sales districts. Considering the capabilities of the salesman and the nature of districts, the marketing manager estimates that sales per month (In hundred rupees) for each salesman in each district would be as follows. Find the assignment of salesman to districts that will result in maximum sale.

	A	B	C	D	E
1	32	38	40	28	40
2	40	24	28	21	36
3	41	27	33	30	37
4	22	38	41	36	36
5	29	33	40	35	39

(14 marks**)**

Module 4

17. A manufacturing workshop must process six jobs through two machines, Machine–1 (M_1) and Machine–2 (M2), in the same order M1 → M2. The processing times (in hours) for each job on both machines are given below:

	M_1	M_2
J1	7	9
J2	6	8
J3	8	7
J4	9	6
J5	5	4
J6	4	5

a) Use Johnson's Rule to determine the optimal sequence that minimizes the total completion (makespan) time.
b) Construct the detailed time chart for both machines based on the obtained sequence.
c) Compute the total elapsed time (makespan) for completing all six jobs.
d) Calculate the idle time for Machine–1 and Machine–2 separately.
e) Comment briefly on how Johnson's Rule helps in improving production scheduling efficiency. (14 marks)

OR

18. Explain Monte carlo simulation with a suitable example. (14 marks)

Module 5

19. A service facility receives customers according to a Poisson arrival process at an average rate of $\lambda = 20$ customers per hour. The service mechanism is exponential with a service rate of $\mu = 15$ customers per hour per server. The facility operates with two parallel servers ($c = 2$), and customers are served on a first-come, first-served (FCFS) basis following an M/M/c queuing model with infinite queue capacity.

(a) Compute the traffic intensity (ρ) of the system.
(b) Determine the probability that an arriving customer has to wait for service.
(c) Compute the following steady-state performance measures:
L = average number of customers in the system
Lq = average number of customers in the queue
W = average time a customer spends in the system

Wq = average waiting time in the queue

(d) Based on the above results, interpret the performance of the system and comment on whether two servers are adequate for the given arrival and service rates.

(14 Marks)

OR

20. A company is evaluating two strategic options, Strategy A_1 and Strategy A_2, against three possible competitive responses from a rival firm, B_1, B_2, and B_3. The corresponding payoff matrix (payoffs to Player A) is given below:

	B_1	B_2	B_3
A_1	4	2	6
A_2	3	5	1

(a) Reduce the payoff table, if possible, using dominance.

(b) Using the graphical method, solve the reduced 2×3 game to determine:

(i) the optimal mixed strategy for Player A

(ii) the optimal mixed strategy for Player B

(iii) the value of the game

(c) Draw and label the relevant graph clearly to show the intersection point used to solve the game.

(14 Marks)

B24ME3G12	INTRODUCTION TO PRODUCT DEVELOPMENT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The course aims to provide creativity and confidence in developing innovative products. It introduces students to systematic methods, tools, and strategies used in product design and development. Emphasis is placed on integrating conceptualization, design thinking, engineering principles, and practical implementation to transform ideas into viable products that meet user needs and market demands.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the stages of the product life cycle and the steps involved in the product development process. (Cognitive Knowledge Level: Understand)
CO 2	Apply principles of conceptual design and robust design techniques to develop effective product design solutions. (Cognitive Knowledge Level: Apply)
CO 3	Describe the principles and importance of Design for Manufacturing and Assembly (DFMA) in product design. (Cognitive Knowledge Level: Understand)
CO 4	Apply value engineering techniques to improve product functionality while minimizing cost. (Cognitive Knowledge Level: Apply)
CO 5	Apply concurrent engineering, rapid prototyping, and reverse engineering concepts to develop innovative product solutions. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	2	1	1	–	–	–	–	–	–	–	1
CO 2	3	2	3	2	2	–	–	–	–	–	1
CO 3	2	1	2	–	1	2	–	–	–	–	–
CO 4	2	2	2	–	–	1	–	–	–	3	–
CO 5	2	2	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	60	60	40
Apply	20	20	40
Analyse			
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Fundamentals of Product Design and Development (7 hours)

Introduction: Classification/ Specifications of Products, Product life cycle, product mix.
Introduction to product design, Modern product development process. Design by evolution, Design by innovation, Morphology of design.
Development Processes: A generic development process, concept development: the front-end process, product development process flow.

MODULE 2: Creativity, Conceptual Design, and Robust Product Development (7 hours)

Creativity Techniques: Creative thinking, conceptualization, brain storming, primary design, drawing, simulation, detail design.
Conceptual Design: Generation, selection & embodiment of concept,
Product architecture.
Industrial design: process, need.
Robust Design: Taguchi Designs, Design of experiments.

MODULE 3: Design for Manufacturability, Sustainability, and User Experience (7 hours)

Design for Manufacturing and Assembly: Methods of designing for Manufacturing and Assembly.
Design for Maintenance. Design for Environment.
Ergonomics in product design.
Aesthetics in product design. Concepts of size and texture color.

MODULE 4: Value Engineering and Economic Aspects of Product Design (7 hours)

Value Engineering / Value Analysis: Definition. Methodology, Case studies.
Product costing.
Economic analysis: Qualitative & Quantitative.
Psychological and Physiological considerations.

MODULE 5: Advanced Product Development Tools and Engineering Practices (8 hours)

Concurrent Engineering -Elements of concurrent engineering, Benefits
Rapid prototyping: concepts, processes and advantages.
Reverse engineering: steps in reverse engineering- hardware and software in reverse engineering.
Tools for product design – Drafting / Modeling software.
Patents & IP Acts. Overview, Disclosure preparation.

Text Books

1. Karl T Ulrich, Steven D Eppinger, *Product Design & Development*, Tata McGraw Hill.
2. George E Deiter, *Engineering Design*, McGraw-Hill.

Reference Books

1. Baldwin E N & Neibel B W, *Designing for Production*, Edwin Homewood Illinois.

2. Bralla J G (Ed.), *Handbook of Product Design for Manufacture*, McGraw Hill, NewYork.
3. D. T. Pham, S.S. Dimov, *Rapid Manufacturing-The Technologies and Applications of Rapid Prototyping and Rapid Tooling*, Springer – Verlag, London.
4. David G Ullman, *The Mechanical Design Process*, McGraw Hill Inc Singapore.
5. Hollins B & Pugh S, *Successful Product Design*, Butter worths London.
6. Jones J C, *Design Methods: Seeds of Human Futures*, John Willey.
7. Kevin Otto & Kristin Wood, *Product Design: Techniques in Reverse Engineering and new Product Development*, Pearson Education New Delhi.
8. N J M Roozenberg, J Ekels, N F M Roozenberg, *Product Design Fundamentals and Methods*, John Willey & Sons.
9. Andreas Gebhardt, *Rapid Prototyping*, Carl Hanser -Verlag, Munich.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Introduction: Classification/ Specifications of Products. Product life cycle.	2
1.2	Product mix. Introduction to product design. Modern product development process. Design by evolution, Design by innovation, Morphology of design.	2
1.3	Innovative thinking. Morphology of design.	1
1.4	Development Processes: A generic development process, concept development: the front-end process, product development process flow.	2
	Module 2	**7**
2.1	Creativity Techniques: Creative thinking, conceptualization, brain storming, primary design, drawing, simulation, detail design.	2
2.2	Conceptual Design: Generation, selection & embodiment of concept, Product architecture.	2
2.3	Industrial design: process, need.	1
2.4	Robust Design: Taguchi Designs, Design of experiments.	2
	Module 3	**7**
3.1	Design for Manufacturing and Assembly: Methods of designing for Manufacturing and Assembly.	2
3.2	Design for Maintenance. Design for Environment.	2
3.3	Ergonomics in product design.	1
3.4	Aesthetics in product design. Concepts of size and texture color.	2
	Module 4	**7**
4.1	Value Engineering / Value Analysis: Definition. Methodology, Case studies. Product costing.	3
4.2	Economic analysis: Qualitative & Quantitative.	2

4.3	Psychological and Physiological considerations.	2
	Module 5	**8**
5.1	Concurrent Engineering -Elements of concurrent engineering, Benefits	2
5.2	Rapid prototyping: concepts, processes and advantages.	2
5.3	Reverse engineering: steps in reverse engineering- hardware and software in reverse engineering.	1
5.4	Tools for product design – Drafting / Modeling software.	2
5.5	Patents & IP Acts. Overview, Disclosure preparation.	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Analyse the steps and responsibilities involved in the development of a new product with the help of an example?
2. Define the Product Development Process and explain the various phases of the generic development process.
3. With the help of examples explain the design by evolution and design by innovation approach.

Course Outcome 2 (CO2):

1. Explain the various processes involved in the Industrial Design.
2. What is meant by Product Architecture? Describe the steps involved in Product Architecture?
3. Interpret embodiment of concept in product design with suitable example.

Course Outcome 3 (CO3):

1. Show the design of a simple sofa and then depict how the design changes when considering 1) aesthetics and 2) ergonomics into consideration. Give hand sketches and explanations to justify the changes in designs.
2. Design a chair for a computer operator based on the ergonomic aspect.
3. Discuss the impact of manufacturing industry in environment and how it can be minimized.

Course Outcome 4 (CO4):

1. Explain the concept of Value Engineering. Discuss with suitable case studies.
2. Describe the how to estimate the cost of a particular design using ANY of the following: i) a website, ii) the layout of a plant, iii) the elevation of a building, iv) an electrical or electronic system or device and v) a car. Show how economics will influence the engineering designs. Use hand sketches to support your arguments.

3. Explain the role of physiological considerations in product design.

Course Outcome 5 (CO5)

1. Discuss briefly reverse engineering approach in product design. What are its advantages?
2. List out the classification of rapid prototyping (RP) technology? Illustrate any two types of RP applications with the help of sketches.
3. Apply the concept of reverse-engineering in the development of a product with the help of an example.

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: **B24ME3G12**

Course Name: **INTRODUCTION TO PRODUCT DEVELOPMENT**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Explain the term product mix in product design with a suitable example.

2 Explain 'Product Life Cycle' of a manufactured product.

3 Demonstrate parameter diagram used in robust design with the help of examples.

4 What is the need for a Conceptual Design in the product design process.

5 Explain the term anthropometry and elaborate on the importance of anthropometry in ergonomics.

6 List the merits of Design for Manufacturing and Assembly (DFMA).

7 Differentiate between quantitative and qualitative economic analysis.

8 List the benefits and drawbacks of value engineering?

9 Outline the role of modelling software in product design.

10 List out the steps involved in the preparation of a patent disclosure.

PART B

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

Module 1

11 a. Analyze the steps involved in the development of a new product with the help of an example? (7 marks)

b. With the help of a neat sketch explain the Product Life Cycle. (7 marks)

OR

12 With the help of examples explain the design by evolution and design by innovation approach. (14 marks)

Module 2

13 What is meant by Product Architecture? Describe the steps involved in Product Architecture? (14 marks)

OR

14 What do you mean by Industrial Design and the steps involved in the industrial design process. (14 marks)

Module 3

15 a. What are the similarities and differences of DFA (Design for Assembly) and DFM (Design for Manufacturing)? (7 marks)

b. Design a chair for a computer operator based on the ergonomic aspect. (7 marks)

OR

16 a. Discuss the impact of manufacturing industry in environment and how it can be minimized. (7 marks)

b. How does the ergonomics and aesthetics aspect influence the product design? (7 marks)

Module 4

17 Explain the concept of Value Engineering. Discuss with suitable case studies. (14 marks)

OR

18 Explain the use of FAST diagram in value engineering. What are its advantages? (14 marks)

Module 5

19 Discuss briefly reverse engineering approach in product design. What are it advantages? (14 marks)

OR

20 List out the classification of rapid prototyping (RP) technology? Illustrate any two types of RP applications with the help of sketches. (14 marks)

B24ME3G13	OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces fundamental principles of occupational health and safety essential for engineering practice. It focuses on hazard identification, risk assessment, safety control measures, legal compliance, and professional responsibility. The course prepares engineering graduates to design and operate safe, sustainable, and ethically responsible engineering systems.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain fundamental occupational health and safety concepts, legal frameworks, standards, and OHS management systems applicable to engineering practice. (Cognitive Knowledge Level: Understand)
CO 2	Explain workplace hazards and risk assessment concepts using qualitative and quantitative methods and incident investigation techniques. (Cognitive Knowledge Level: Understand)
CO 3	Outline engineering safety principles and control measures for machinery, fire, explosion, and electrical hazards. (Cognitive Knowledge Level: Understand)
CO 4	Explain occupational hygiene, ergonomic, and human factor issues and their role in improving workplace safety and system performance (Cognitive Knowledge Level: Understand)
CO 5	Demonstrate professional safety practices through environmental safety integration, emergency preparedness, documentation, audits, and case study analysis. (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	1	–	3	2	2	–	1	1
CO 2	3	3	2	3	2	2	2	2	–	1	1
CO 3	3	3	3	2	2	2	2	2	–	1	1
CO 4	2	3	2	2	1	3	2	2	–	1	1
CO 5	2	2	2	2	1	3	3	3	1	2	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	60
Apply			
Analyse			
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Foundations of Occupational Health and Safety (7 Hours)

OHS concepts – hazard, risk, accident, incident, near miss, exposure; hazard identification, risk assessment and control; Safety by Design, life cycle safety; national and international OHS legislations; roles and responsibilities of employer, designer, contractor and engineer; due diligence and duty of care; safety standards – BIS, ANSI, ISO, NFPA, IEC; OHS management systems – PDCA cycle, ISO 45001, integration with QMS and EMS.

Module 2: Hazard Identification and Risk Assessment (7 Hours)

Hazard identification techniques – JSA, JHA, PHA, HAZOP, FMEA, Bow-Tie analysis; qualitative and quantitative risk assessment; risk estimation using probability, severity and exposure; risk evaluation using ALARP principle; risk matrix and consequence modeling; incident investigation models – Domino, Swiss Cheese, Energy Release; root cause analysis – FTA, ETA, 5 Whys, Fishbone diagram.

Module 3: Technical Safety Engineering (8 Hours)

Hierarchy of controls – elimination, substitution, engineering, administrative controls and PPE; machinery safety – guarding, inspection, lockout/tagout; safety of pressure vessels, boilers, cranes and lifting equipment; fire and explosion safety – fire chemistry, detection and suppression systems, ATEX compliance, dust explosion control; electrical safety – earthing, bonding, insulation, circuit protection and IEC/IEEE standards.

Module 4: Occupational Hygiene, Ergonomics and Human Factors (7 Hours)

Occupational hygiene – physical, chemical and biological hazards; exposure limits – TLV, PEL, OEL; engineering controls – ventilation, noise control, vibration isolation; ergonomics – anthropometry, workplace and human–machine interface design; manual handling, repetitive strain and MSD prevention; construction and project safety – excavation, working at height, scaffolding, confined spaces and permit-to-work systems.

Module 5: Environmental, Emergency and Professional Safety Practice (7 Hours)

Environmental Health and Safety principles; hazardous and non-hazardous waste management; spill prevention and control; sustainable and green engineering practices; emergency preparedness – emergency response plans, roles and shutdown procedures; crisis communication and disaster recovery; safety documentation, audits, inspections and performance metrics; industrial safety case studies – Bhopal Gas Tragedy, Texas City Refinery, Rana Plaza Collapse.

Textbooks

1. David L. Goetsch, Occupational Safety and Health for Technologists, Engineers and Managers, Pearson Education.
2. Mistry K U & Bhandari R M., Industrial Safety and Environment, Khanna Publishers.
3. L. M. Deshmukh, Industrial Safety Management, McGraw Hill Education (Ind) Pvt. Ltd.

References

1. R. K. Jain & Sunil S. Rao, Handbook of Industrial Safety, Khanna Publishers, New Delhi.
2. Mark A. Friend & James P. Kohn, Fundamentals of Occupational Safety and Health
3. Government Institutes / Rowman & Littlefield, USA
4. Roger L. Brauer, Safety and Health for Engineers, John Wiley & Sons, USA
5. Occupational Safety, Health and Working Conditions Code, 2020 – Govt. of India.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Introduction to OHS, hazard, risk, accident, incident, near miss, hazard identification and control	2
1.2	Safety by Design, life cycle safety, roles and responsibilities, due diligence, duty of care	2
1.3	Indian OHS legislation, OSH Code 2020, Factories Act, BIS/ISO/NFPA/IEC standards, ISO 45001 and PDCA	3
	Module 2	**7**
2.1	JSA, JHA, PHA and basic hazard identification techniques	2
2.2	HAZOP, FMEA, Bow-Tie analysis	2
2.3	Qualitative vs quantitative risk assessment, ALARP, risk matrix, accident causation models, root cause analysis	3
	Module 3	**8**
3.1	Hierarchy of controls, PPE, machinery guarding principles	2
3.2	Lockout/Tagout, pressure vessels, boilers, cranes and lifting equipment	2
3.3	Fire chemistry, fire detection and suppression systems	2
3.4	Explosion safety, ATEX, electrical hazards, earthing and circuit protection	2
	Module 4	**7**
4.1	Physical, chemical, biological hazards, exposure limits (TLV, PEL, OEL)	2
4.2	Ventilation systems, noise and vibration control	2
4.3	Ergonomics, anthropometry, human–machine interface, manual handling, MSD prevention, construction safety	3
	Module 5	**7**
5.1	EHS principles, waste management, SPCC, sustainable engineering	2
5.2	Emergency response planning, shutdown procedures, crisis communication	2
5.3	Safety documentation, audits, inspections, performance metrics, industrial case studies	3
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Define hazard and risk. Explain their relationship with a suitable workplace example.
2. What is Safety by Design (SbD)? State its importance in engineering systems.
3. Explain the PDCA cycle in the context of an Occupational Health and Safety Management System.

Course Outcome 2 (CO2):

1. What is Job Safety Analysis (JSA)? List its main steps.
2. Distinguish between qualitative and quantitative risk assessment.
3. Explain the ALARP principle used in risk evaluation.

Course Outcome 3 (CO3):

1. Explain the Hierarchy of Controls with suitable examples.
2. What is Lockout/Tagout (LOTO)? State its purpose in machinery safety.
3. List any three fire detection or suppression systems used in industries.

Course Outcome 4 (CO4):

1. Define occupational hygiene and list any two types of workplace hazards.
2. What are TLV and PEL? Mention their significance in exposure control.
3. Explain the role of ergonomics in preventing musculoskeletal disorders.

Course Outcome 5 (CO5)

1. What is an Emergency Response Plan (ERP)? List its key components.
2. State the objectives of safety audits and inspections.
3. Mention any three lessons learned from the Bhopal Gas Tragedy.

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: **B24ME3G13**

Course Name: **OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What is Safety by Design (SbD)? State its importance in engineering systems.
2. Explain the PDCA cycle in the context of an Occupational Health and Safety Management System.
3. What is Job Safety Analysis (JSA)? List its main steps.
4. Distinguish between qualitative and quantitative risk assessment.
5. What is Lockout/Tagout (LOTO)? State its purpose in machinery safety.
6. List any three fire detection or suppression systems used in industries.
7. Define occupational hygiene and list any two types of workplace hazards.
8. What are TLV and PEL? Mention their significance in exposure control.
9. What is an Emergency Response Plan (ERP)? List its key components.
10. State the objectives of safety audits and inspections.

PART B

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

Module 1

11 a. Explain the key concepts of occupational health and safety, namely hazard, risk, accident, incident, near miss, and exposure. (6 marks)

b. Discuss the role of engineers in ensuring legal compliance through due diligence and duty of care in engineering projects. (8 marks)

OR

12 a. Describe the Plan–Do–Check–Act (PDCA) cycle with respect to an OHS management system. (6 marks)

b. Explain the structure and significance of ISO 45001 and its integration with quality and environmental management systems (8 marks)

Module II

13 a. Explain the steps involved in Job Safety Analysis (JSA) and Hazard and Operability Study (HAZOP). (8 marks)

b. b) Illustrate the application of the ALARP principle in risk evaluation using a suitable example. (6 marks)

OR

14 a. Describe qualitative and quantitative risk assessment methods used in engineering industries. (7 marks)

b. Explain accident causation models and root cause analysis techniques used in incident investigation. (7 marks)

Module III

15 a. Explain the hierarchy of controls with suitable industrial examples. (8 marks)

b. Discuss machinery safety measures including machine guarding and lockout/ tagout procedures. (6 marks)

OR

16 a. Explain the principles of fire chemistry and fire prevention in industrial environments. (7 marks)

b. Discuss explosion protection methods and electrical safety measures adopted in engineering systems. (7 marks)

Module IV

17 a. Explain the types of occupational hazards and methods of exposure assessment. (7 marks)

b. Discuss engineering control measures used to reduce noise, vibration, and airborne contaminants. (7 marks)

OR

18 a. Explain ergonomic principles used in workplace and equipment design. (7 marks)

b. Discuss human factors and manual handling practices for the prevention of musculoskeletal disorders. (7 marks)

Module V

19 a. Explain the principles of Environmental Health and Safety (EHS) and hazardous waste management. (7 marks)

b. Discuss sustainable and green engineering practices in relation to occupational safety. (7 marks)

OR

20 a. Describe the components of an Emergency Response Plan (ERP) for an industrial facility (8 marks)

b. Discuss the role of safety audits, inspections, and documentation in professional safety practice with reference to an industrial accident case study (6 marks)

B24ME3G14	AUTOMOTIVE TECHNOLOGY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble:

This course introduces the fundamental systems of an automobile, focusing on their layout, working principles, and integration. It covers internal combustion engines, fuel supply and ignition systems, transmission, suspension, braking, and steering systems, highlighting both conventional and modern automotive technologies. The course also provides an overview of electric vehicle technology, automotive safety, comfort, and security systems, reflecting current industry trends and future mobility needs. It equips students with essential knowledge to understand, analyze, and apply automobile systems in engineering practice.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the layout and working principles of SI and CI engines, fuel supply, ignition, supercharging, and emission control systems (Cognitive Knowledge Level: Understand)
CO 2	Explain and apply the operating principles of clutch and transmission systems, including manual and automatic gearboxes, to automobile power transmission (Cognitive Knowledge Level: Apply).
CO 3	Explain and apply the principles of suspension and braking systems, including suspension geometry, drum and disc brakes, and ABS, for vehicle stability and safety (Cognitive Knowledge Level: Apply).
CO 4	Apply steering geometry concepts and explain electric vehicle architecture, energy storage systems, and emerging EV technologies (Cognitive Knowledge Level: Apply).
CO 5	Explain and apply automotive safety, comfort, and security systems in improving vehicle performance, passenger protection, and convenience (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	–	–	1	1	–	–	–	–	1
CO 2	3	2	–	–	2	–	–	–	–	–	1
CO 3	3	2	–	–	2	2	–	–	–	–	1
CO 4	3	2	1	–	2	2	–	–	–	–	2
CO 5	2	1	–	–	1	3	1	–	–	–	2

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	20	10	10
Understand	40	30	30
Apply	40	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Automobile system layout (7 Hours)

Automobile system layout- Engine and its components, SI and CI engine working principle. Fuel supply and injection system-comparison, multiport fuel injection (MPFI) and common rail direct injection (CRDI) systems.

Ignition system. Super charging systems: fundamentals, naturally aspirated engines and supercharged engines– Turbo charger, turbo lag. Engine emission and standards.

MODULE 2: Clutch and Transmission (7 Hours)

Friction clutch: Principle, dry friction clutches- Pull type diaphragm clutch, multiple diaphragm clutch, multi-plate clutch, semi centrifugal clutch, fully automatic centrifugal clutch, and integral single plate diaphragm clutch. Electromagnetic clutch operation, wet clutch, clutch friction materials, fluid friction coupling.

Manual transmission- Resistances offered to motion, Need of gear box, power to weight ratio, speed operating range-five speed and reverse sliding mesh, constant mesh, and synchromesh gear boxes. Automatic transmission- Epicyclic gear box - torque convertor – Over drives.

MODULE 3: Suspension and Brakes (7 Hours)

Suspension system: - Types of suspension springs, suspension geometry and terminology, types of suspension systems, independent suspension, Antiroll bar, Hydro-pneumatic suspension, suspension roll center and body roll.

Brakes: Principle of brake, classification of brakes-mechanical and hydraulic brakes- Drum and Disc brakes, properties of friction lining and pad materials, Anti-Lock Braking system (ABS). Principle of operation and types of ABS.

MODULE 4: Steering and Electric vehicle technology (8 Hours)

Steering: -basic principle of a steering system– Ackermann –over steer and under steer – Steering geometry -slip angle, camber, king pin inclination, caster, toe-in and toe-out. Steering gear box–types- need of power assisted steering.

Electric Vehicle Technology (EVT): EV Architecture, types of batteries, battery parameters, super capacitors. Introduction to Fuel cells. EV Chassis – requirements, suspension for EVs. Recent Electric vehicles- Electric mobility aids. Future of electric vehicles.

MODULE 5: Safety, Control and Security in automobiles (7 Hours)

Safety-Active and passive safety, air bags, seat belt requirements. Forward collision warning system, child lock, advanced safety systems.

Comfort system –Automotive air-conditioning, aerodynamics lift and drag reduction, adaptive cruise control, tiltable steering column, power window, power assisted mirrors and advanced comfort systems.

Security system -Anti theft technology-mechanical, electromechanical and electronic immobilizers, alarm system and remote keyless entry.

Text Books

1. Heinz Heisler, *Vehicle and engine technology*, Butterworth-Heinemann.
2. R.B. Gupta., *Auto design*, Satya Prakashan Publishers, New Delhi.
3. James Larminie and John Lowry, *Electric vehicle technology explained*, Wiley publications.
4. Kirpal Singh, *Automobile Engineering* Vol.1 & Vol.2, Standard Publishers.

Reference Books

1. V.A.W. Hillier, *Fundamentals of modern vehicle technology*, Butterworth-Heinemann.
2. Tom Denton, *Electric and Hybrid Vehicles*, Routledge Publishers.
3. Ljubo Vlacic, Michel Parent and Fumio Harashima, *Intelligent vehicle technologies*, Butterworth-Heinemann publications, Oxford.
4. Shimo Kim and Rakesh Shresta, *Automotive Cyber Security: Introduction Challenges and Standardization,* Springer, Singapore.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Engine and its components- IC engines, piston, rings, pin, flywheel, connecting rod.	1
1.2	SI and CI engine, working principle.	1
1.3	Fuel supply and injection system.	1
1.4	MPFI and CRDI systems.	1
1.5	Ignition systems.	1
1.6	Super charging and Turbocharging systems	1
1.7	Engine emission and standards.	1
	Module 2	**7**
2.1	Principle of dry friction clutches- Single plate clutch, Multi plate hydraulically operated automatic transmission clutch.	1
2.2	Semi centrifugal clutch, fully automatic centrifugal clutch.	1
2.3	Integral single plate diaphragm clutch, Electromagnetic clutch.	1
2.4	Clutch friction materials, wet clutches, fluid friction coupling.	1
2.5	Resistance to Motion, Need of gear box, power to weight ratio, speed operating range. Sliding mesh boxes.	1
2.6	Constant mesh and Synchromesh gear box and Epicyclic gear box.	1
2.7	Over drives, Torque convertor.	1
	Module 3	**7**
3.1	Suspension system: - Types of suspension springs, suspension geometry and terminology.	1

3.2	Types of suspension systems, independent suspension.	1
3.3	Antiroll bar, Hydrogen suspension, hydro pneumatic suspension.	1
3.4	Suspension roll center and body roll.	1
3.5	Brakes: Principle of brake, classification of brakes, mechanical and hydraulic brakes.	1
3.6	Drum and Disc brakes, properties of friction lining and pad materials.	1
3.7	Anti-Lock Braking system (ABS), principle of operation and types of ABS.	1
	Module 4	**8**
4.1	Ackermann steering mechanism, over steer and under steer.	1
4.2	Steering geometry -slip angle, camber, king pin inclination, caster, toe-in and toe-out.	1
4.3	Steering gear box, Types of steering gear box, need of power assisted steering.	1
4.4	EV Architecture, types of batteries, battery parameters.	1
4.5	Super capacitors, Fuel cells.	1
4.6	EV Chassis – requirements, suspension for EVs. Recent Electric vehicles- Electric mobility aids.	1
4.7	Future of electric vehicles.	1
4.8	Future of electric vehicles, EV Tyre wear.	1
	Module 5	**7**
5.1	Safety-Active and passive safety, air bags, seat belt tightening system.	1
5.2	Forward collision warning system, child lock antilock braking system.	1
5.3	Comfort system - Automotive air-conditioning, aerodynamics lift and drag reduction,	1
5.4	Adaptive cruise control, tilt-able steering column, power window and advanced comfort system.	1
5.5	Anti-theft technology-mechanical, electromechanical and electronic immobilizers.	1
5.6	Anti-theft technology-mechanical, electromechanical and electronic immobilizers.	1
5.7	Alarm system and remote keyless entry.	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Compare and contrast the working principles of Spark Ignition (SI) and Compression Ignition (CI) engines, highlighting their key differences in fuel ignition and combustion processes.
2. Explain the fundamental differences between Multiport Fuel Injection (MPFI) and Common Rail Direct Injection (CRDI) systems. Discuss their respective advantages and disadvantages in terms of fuel efficiency, emissions, and performance.
3. Describe the concept of supercharging in internal combustion engines. Differentiate between naturally aspirated and supercharged engines, and explain the mechanism of a turbocharger, including the phenomenon of turbo lag and methods to mitigate it.

Course Outcome 2 (CO2):

1. How does the Pull-Type diaphragm clutch differ mechanically from the standard Push-Type during disengagement?
2. In an Epicyclic (Planetary) Gearbox, what happens if the Ring Gear is held stationary while the Sun Gear acts as the input?
3. What is the specific function of the "Overdrive" gear in a transmission system?

Course Outcome 3 (CO3):

1. Explain Suspension geometries.
2. Explain hydropneumatics suspension system.
3. Describe the need for ABS systems in modern cars.

Course Outcome 4 (CO4):

1. What is Ackerman steering geometry?
2. Discuss the advantages of power assisted steering.
3. Explain the difference between drum and disc brakes.

Course Outcome 5 (CO5)

1. Comment on active and passive safety.
2. What is adaptive cruise control system.
3. Explain the use of of immobilizers in automobiles.

MODEL QUESTION PAPER

QP CODE: Pages: 2

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SIXTH SEMESTER B TECH DEGREE EXAMINATION, MAY 2027

Course Code: **B24ME3G14**

Course Name: **AUTOMOTIVE TECHNOLOGY**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Explain turbocharger lag and the methods to reduce it.
2 Identify the difference between SI and CI engine.
3 Describe automated manual transmission.
4 Explain the principle of dry friction clutch.
5 Compare between drum and disc brakes.
6 Summarize the features of hydro pneumatic suspension system.
7 Indicate the advantage of EV over conventional IC engines.
8 Explain Ackermann principle in steering mechanism system.
9 Explain the working of remote keyless entry in a vehicle.
10 Describe the child lock safety system.

PART B

Answer all questions. Each question carries 14 marks.

Module 1

11 Distinguish between MPFI and CRDI systems. (14 Marks)

OR

12 Explain the working and advantages of turbocharger with a neat sketch. (14 Marks)

Module 2

13 Discuss the working of Pull type diaphragm clutch with a neat sketch. (14 Marks)

OR

14 Explain the need of a gear box and the working of Syncromesh Gear box. (14 Marks)

Module 3

15 a) Represent the features of McPherson strut suspension system with a neat sketch. (7 Marks)

b) Explain the function of an antiroll bar in a four wheeled vehicle. (7 Marks)

OR

16 a) Discuss the working and advantages of ABS over conventional systems. (7 Marks)

b) Explain the properties of friction lining and pad materials. (7 Marks)

Module 4

17 a) Differentiate between over steering and under steering. (7 Marks)

b) Illustrate the rack and pinion steering gear box system. (7 Marks)

OR

18 a) Explain the basic principle of a hydrogen fuel cell and its efficiency. (7 Marks)

b) Indicate different type of batteries used in an electric vehicle. (7 Marks)

Module 5

19 a) Explain the air conditioning system in an automobile. (7 Marks)

b) Discuss the methods to control the aerodynamic lift in vehicles. (7 Marks)

OR

20 a) Classify active and passive safety systems in a car. (7 Marks)

b) Explain how an electronic immobilizer can prevent the vehicle theft. (7 Marks)

B24ME3G15	NON-DESTRUCTIVE TESTING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Non-Destructive Testing (NDT) plays a vital role in assessing the condition and integrity of materials, components, and structures without impairing their usability. It is widely employed to ensure safety, quality, and reliability in industries such as manufacturing, construction, aerospace, and energy. This course introduces the fundamental principles, procedures, and applications of major NDT techniques, enabling students to recognize defects, interpret inspection results, and select suitable testing methods. The course equips learners with essential knowledge and practical insight required for effective inspection and maintenance of engineering systems.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the basic principles, need, and significance of non-destructive testing in engineering applications (Cognitive Knowledge Level: Understand).
CO 2	Explain the working principles, procedures, and limitations of commonly used non-destructive testing techniques (Cognitive Knowledge Level: Understand).
CO 3	Interpret results and indications obtained from visual, liquid penetrant, magnetic particle, eddy current, radiographic, and ultrasonic testing methods (Cognitive Knowledge Level: Apply).
CO 4	Select and apply appropriate non-destructive testing methods based on material type, nature of defects, accessibility, and cost considerations (Cognitive Knowledge Level: Apply).
CO 5	Apply relevant codes, standards, and safety practices while performing and interpreting non-destructive testing in practical engineering situations (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	1	1					1		1
CO 2	3	2	1	1					1		1
CO 3	3	3	1	2	1				1		1
CO 4	3	3	2	1	2				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	40	30	30
Understand	60	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Introduction to Non-Destructive Testing (7 Hours)

Definition, need, and importance of NDT, Comparison between destructive and non-destructive methods, Classification of NDT methods, Material discontinuities and defects: types and causes, General characteristics of NDT methods, Standards and codes (ASNT, ASTM, ISO), Applications of NDT in manufacturing, maintenance, and service industries.

Module 2: Visual Inspection and Liquid Penetrant Testing (7 Hours)

Visual Inspection (VI): Equipment, lighting, mirrors, magnifying tools, and surface preparation, Visual inspection aids such as bore scopes and fiberscopes, Limitations and applications of VI, Liquid Penetrant Testing (LPT): Principle, types of penetrants and developers, Process steps: cleaning, application, penetration, removal, developer application, inspection, post-cleaning, Sensitivity levels, interpretation, and evaluation of results, Advantages, limitations, and applications of LPT.

Module 3: Magnetic Particle and Eddy Current Testing (7 Hours)

Magnetic Particle Testing (MPT): Principle of magnetization, methods (circular, longitudinal), magnetic particles (dry and wet methods), equipment and accessories, Indications, interpretation, demagnetization, and safety precautions, Advantages, limitations, and typical applications, Eddy Current Testing (ECT): Principle of electromagnetic induction, eddy current generation and detection, coil arrangements, Factors affecting sensitivity and resolution, Applications: crack detection, conductivity measurement and coating thickness measurement.

Module 4: Radiographic Testing (7 Hours)

Principle of radiography using X-rays and Gamma rays, Equipment: X-ray tubes, radioactive isotopes, detectors, and imaging systems, Radiographic film and digital radiography, Image formation and interpretation, Exposure techniques, sensitivity, and resolution, Types of defects revealed by radiography, Safety aspects in radiography and radiation protection, Applications, advantages and limitations of radiographic testing.

Module 5: Ultrasonic Testing (8 Hours)

Ultrasonic Testing (UT): Basic principles, wave types, reflection and refraction, pulse-echo and through-transmission methods, Equipment, couplants, and calibration procedures, A-scan, B-scan, and C-scan representations, Defect characterization and result interpretation, Advantages and limitations of UT.

Textbooks

1. Baldev Raj, T. Jayakumar, & M. Thavasimuthu, *Practical Non-Destructive Testing*, Narosa Publishing House.
2. Charles Hellier, *Handbook of Non-Destructive Evaluation*, McGraw-Hill.
3. J. Prasad & C. G. K. Nair, *Non-Destructive Test and Evaluation of Materials*, Tata McGraw-Hill.

Reference Books

1. ASM Handbook, *Vol. 17: Nondestructive Evaluation of Materials*, ASM International.
2. Paul E. Mix, *Introduction to Non-Destructive Testing: A Training Guide*, Wiley.
3. Josef Krautkrämer & Herbert Krautkrämer, *Ultrasonic Testing of Materials*, Springer.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Definition, need, and importance of NDT, Comparison between destructive and non-destructive methods,	2
1.2	Classification of NDT methods, Material discontinuities and defects: types and causes	2
1.3	General characteristics of NDT methods, Standards and codes (ASNT, ASTM, ISO)	2
1.4	Applications of NDT in manufacturing, maintenance, and service industries	1
	Module 2	**7**
2.1	Visual Inspection (VI): Equipment, lighting, mirrors, magnifying tools, and surface preparation, Visual inspection aids such as bore scopes and fiberscopes, Limitations and applications of VI	2
2.2	Liquid Penetrant Testing (LPT): Principle, types of penetrants and developers	2
2.3	Process steps: cleaning, application, penetration, removal, developer application, inspection, post-cleaning, Sensitivity levels, interpretation, and evaluation of results	2
2.4	Advantages, limitations, and applications of LPT	1
	Module 3	**7**
3.1	Magnetic Particle Testing (MPT): Principle of magnetization, methods (circular, longitudinal), magnetic particles (dry and wet methods)	2
3.2	Equipment and accessories, Indications, interpretation, demagnetization, and safety precautions, Advantages, limitations, and typical applications	2
3.3	Eddy Current Testing (ECT): Principle of electromagnetic induction, eddy current generation and detection, coil arrangements, Factors affecting sensitivity and resolution	2
3.4	Applications: crack detection, conductivity measurement and coating thickness measurement	1
	Module 4	**7**
4.1	Principle of radiography using X-rays and Gamma rays, Equipment: X-ray tubes, radioactive isotopes, detectors, and	2

	imaging systems	
4.2	Radiographic film and digital radiography, Image formation and interpretation, Exposure techniques, sensitivity, and resolution	2
4.3	Types of defects revealed by radiography, Safety aspects in radiography and radiation protection	2
4.4	Applications, advantages and limitations of radiographic testing	1
	Module 5	**8**
5.1	Ultrasonic Testing (UT): Basic principles, wave types, reflection and refraction	2
5.2	Pulse-echo and through-transmission methods	2
5.3	Equipment, couplants, and calibration procedures, A-scan, B-scan, and C-scan representations,	2
5.4	Defect characterization and result interpretation	1
5.5	Advantages and limitations of UT	1
	Total	**36 hours**

MODEL QUESTION PAPER

QP CODE: Pages: 2

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Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SIXTH SEMESTER B TECH DEGREE EXAMINATION, MAY 2027

Course Code: **B24ME3G15**

Course Name: **NON-DESTRUCTIVE TESTING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Differentiate between destructive and non – destructive testing.

2 Write short notes about any 3 types of ISO standards for NDT testing.

3 Write short notes about various tools used for visual inspection.

4 Explain the desirable properties of a penetrant.

5 Differentiate between dry and wet type magnetic particle testing.

6 Explain about coating thickness measurement in eddy current testing.

7 Write short notes about different radiography sources.

8 Write down the advantages and disadvantages of radiography testing.

9 Explain about the generation of ultrasonic waves.

10 Write short notes about types of ultrasonic waves.

PART B

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

Module 1

11 Explain about the general characteristics of NDT methods. (14 Marks)

OR

12 Explain about different classifications of NDT techniques. (14 Marks)

Module 2

13 Explain various aspects and types of visual inspection. (14 Marks)

OR

14 With neat sketches explain about liquid penetrant inspection technique. Also list the advantages, disadvantages and applications of the process. (14 Marks)

Module 3

15 Explain about magnetic particle inspection technique. (14 Marks)

OR

16 Explain the process of eddy current testing. Also, list the applications of the process. (14 Marks)

Module 4

17 With neat sketches, explain the working of radiographic testing. (14 Marks)

OR

18 Explain the safety aspects associated with radiography testing. (14 Marks)

Module 5

19 With neat sketches, explain the working principle of ultrasonic testing. (14 Marks)

OR

20 With neat sketches, differentiate between A – scan, B – scan and C – scan in ultrasonic testing. (14 Marks)

B24ME3G16	MATERIAL HANDLING SYSTEMS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Materials handling is the art and science of ensuring the right materials get to the right place at the right time, safely and at the lowest possible cost. A material handling system is a planned, systematic process for moving, storing, protecting, and controlling products throughout the manufacturing, warehousing and distribution chain. This course is designed to provide a comprehensive understanding of the basics of material handling, types of material handling equipment and safety considerations in material handling.

Prerequisites

Nil

Course Outcomes

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

CO1	Interpret and understand the basics of material handling. (Cognitive Knowledge Level: Understand)
CO2	Compare and understand different types of industrial vehicles. (Cognitive Knowledge Level: Understand)
CO3	Compare and understand different types of conveying machinery. (Cognitive Knowledge Level: Understand)
CO4	Compare and understand different types of Hoisting machinery. (Cognitive Knowledge Level: Understand)
CO5	Identify and understand the Safety Considerations in Material Handling. (Cognitive Knowledge Level: Understand and Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	1				1					
CO2	2	2	1	1		2	1		1		1
CO3	2	2	2	2		2	1		1		1
CO4	2	2	2	2		2	1		1		1
CO5	2	2	2	2		2	3		3		2

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	40	40	30
Understand	60	60	50
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 (2numbers) :25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Fundamentals of Materials Handling and Plant Layout (4 hours)

Introduction to Materials Handling: Introduction - objectives of materials handling - principles of material handling - selection of material handling equipments - factors affecting choice of material handling equipments - guidelines for effective utilization of material handling equipments - characteristics and classification of materials – relationship between materials handling and plant layout.

MODULE 2: Industrial Vehicles and Surface Material Handling Equipment (9 hours)

Industrial Vehicles: Introduction and surface transport equipment types - functions - hand trucks – two-wheel hand trucks – multiple wheel hand trucks – hand lift trucks - power trucks – fixed platform truck – platform lift truck – pallet lift truck – fork lift trucks - fork lift truck attachment – tow tractors and trolley – industrial tractor - AGV (Automatic Guided Vehicle) - industrial trailers - cross handling equipment.

MODULE 3: Conveyor Systems and Continuous Handling Equipment (11 hours)

Conveying Machinery: Classification of conveyors - belt conveyors- chain conveyors - bucket conveyors - screw conveyors – roller conveyor - vibrating and oscillating conveyors – pneumatic conveyors – overhead conveyors – wheel conveyor – vertical conveyor – indexing conveyor – chute conveyor – en-masse conveyor – monorail conveyor.

MODULE 4: Hoisting, Lifting, and Vertical Handling Equipment (8 hours)

Hoisting Machinery and Equipments: Classification of cranes used for materials handling – advantages of cranes – important parts of cranes – basic motions of cranes – revolving or rotary cranes – mobile cranes – bridge cranes- lifts - elevators.

MODULE 5: Safety, Standards, and Risk Management in Materials Handling (4 hours)

Safety Considerations in Material Handling: Materials handling safety policy – safety training for material handling – material handling safety procedures – conducting risk assessments and identifying hazards - material handling safety equipments and its proper use – industry standards and regulations.

Text Books

1. Siddhartha Rayl, *Introduction to Materials Handling*, New Age International Publishers.
2. Richard Skib, *Material Handling Equipment Operation,* After Midnight Publishing
3. Keshava Chanda Arora & Vikas V. Shinde, *Aspects of Materials Handling,* Firewall Media.

Reference Books

1. Allegri T. H., *Materials Handling: Principles and Practice,* CBS Publication.
2. Matthew P. Stephens, *Manufacturing Facilities Design & Material Handling,* Purdue University Press.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**4**
1.1	Introduction to Materials Handling: objectives of materials handling; principles of material handling	1
1.2	Selection of material handling equipments; factors affecting choice of material handling equipments	1
1.3	Guidelines for effective utilization of material handling equipments; characteristics and classification of materials; relationship between materials handling and plant layout.	2
	Module 2	**9**
2.1	Industrial Vehicles: Introduction and surface transport equipment types; functions	1
2.2	Hand trucks; two-wheel hand trucks; multiple wheel hand trucks	2
2.3	Hand lift trucks; power trucks; fixed platform truck; platform lift truck	2
2.4	Pallet lift truck; fork lift trucks; fork lift truck attachment; tow tractors and trolley	2
2.5	Industrial tractor; AGV (Automatic Guided Vehicle); industrial trailers; cross handling equipment	2
	Module 3	**11**
3.1	Conveying Machinery: Classification of conveyors; belt conveyors; chain conveyors	2
3.2	Bucket conveyors; screw conveyors; roller conveyor	2
3.3	Vibrating and oscillating conveyors; pneumatic conveyors; overhead conveyors	3
3.4	Wheel conveyor; vertical conveyor; indexing conveyor	2
3.5	Chute conveyor; en-masse conveyor; monorail conveyor	2
	Module 4	**8**
4.1	Hoisting Machinery and Equipments: classification of cranes used for materials handling; advantages of cranes	1
4.2	Important parts of cranes; basic motions of cranes; revolving or rotary cranes; mobile cranes	4
4.3	Bridge cranes; lifts; elevators.	3
	Module 5	**4**
5.1	Safety Considerations in Material Handling: Materials handling safety policy; safety training for material handling	1
5.2	Material handling safety procedures	1
5.3	Conducting risk assessments and identifying hazards	1
5.4	Material handling safety equipments and its proper use; industry standards and regulations	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome1 (CO1):

1. Classify material handling equipment and list any two applications of each equipment.
2. Discuss three factors affecting the selection of material handling equipment and provide two examples of common material handling equipment.
3. Discuss the guidelines for effective utilization of material handling equipment.

Course Outcome 2 (CO2):

1. Differentiate between a standard hand truck and a stair climbing hand truck
2. Explain the types of two-wheel and multiple-wheel hand trucks, their applications, advantages and disadvantages.
3. Highlight three key functions that an AGV performs, distinguishing it from an industrial standard tractor vehicle.

Course Outcome 3 (CO3):

1. Explain the basic working mechanism of screw conveyor. Describe its two main components
2. Describe the working principle of a continuous bucket conveyor. Justify its suitability for handling fragile materials like grains.
3. Explain the working principle of a vibrating conveyor. Discuss any two applications where the vibrating conveyor mechanism offers a significant advantage over other types of conveyors.

Course Outcome 4 (CO4):

1. What are the primary benefits of using a revolving crane in an industrial setting?
2. Illustrate and explain the working mechanism of a bridge crane.
3. Classify cranes based on their mobility.

Course Outcome 5 (CO5)

1. Outline the different types of safety training necessary for employees involved in manual and mechanical material handling. Justify why each training component is essential for preventing workplace injuries.
2. What are the points that a safety inspector should look for to ensure material handling equipment is safe for use?
3. Explain with suitable example the difference between a hazard and a risk

MODEL QUESTION PAPER

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SIXTH SEMESTER BTECH DEGRE E EXAMINATION, MAY 2027

Course Code: **B24ME3G16**

Course Name: **MATERIAL HANDLING SYSTEMS**

Max.Marks:100 Duration: 3 hours

PARTA

Answer all questions. Each question carries 3 marks.

1 Define material handling and list any two of its objectives.

2 Discuss three factors affecting the selection of material handling equipment and provide two examples of common material handling equipment.

3 Differentiate between a standard hand truck and a stair-climbing hand truck.

4 Highlight three key functions that an AGV performs, distinguishing it from an industrial standard tractor vehicle.

5 Differentiate between belt conveyor and chain conveyor.

6 Explain the basic working mechanism of roller conveyor. Describe its two main components.

7 What are the primary benefits of using a revolving crane in an industrial setting?

8 List a few applications of overhead crane.

9 What are the points that should a safety inspector look for to ensure material handling equipment is safe for use.

10 Explain with suitable example the difference between a hazard and a risk.

PARTB

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

Module 1

11 a. Discuss the guidelines for effective utilization of material handling equipment. (7 marks)

b. Discuss the different material handling equipments with suitable examples. (7 marks)

OR

12 a. Discuss the factors to be considered while selecting material handling equipment in a four-wheel automobile service station. (14 marks)

Module 2

13 a. Explain the types of two wheel and multiple wheel hand trucks, their applications, advantages and disadvantages. (14 marks)

OR

14 a. Compare and contrast different types of pallet trucks, detailing their working principles, applications, advantages and disadvantages. (14 marks)

Module 3

15 a. Describe the working principle of a continuous bucket conveyor. Justify its suitability for handling fragile materials like grains. (7 marks)

b. Explain the working principle of a vibrating conveyor. Discuss any two applications where vibrating conveyor mechanism offers a significant advantage over other types of conveyors. (7 marks)

OR

16 a. Discuss the key components of an overhead conveyor and explain the safety features that are essential for its safe operation. (7 marks)

b. With a neat sketch explain the working principle of a monorail conveyor system. Detail its key components and outline its advantages for use in limited floor space. (7 marks)

Module 4

17 a. Illustrate and explain the working mechanism of a mobile crane. (7 marks)

b. Describe the functions of the main components found in a bridge crane. (7 marks)

OR

18 a. Classify cranes based on their mobility. (6 marks)

b. What are the factors that must be considered when designing a lift for a multistory building? (8 marks)

Module 5

19 Outline the different types of safety training necessary for employees involved in manual and mechanical material handling. Justify why each training component is essential for preventing workplace injuries. (14 marks)

OR

20 Explain the proper use and procedures for any three types of material handling safety equipment. (14 marks)

B24ME3G17	FUNDAMENTALS OF DATA ANALYSIS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Fundamentals of Data Analysis is an interdisciplinary course designed to introduce engineering students to the principles and practices of data-driven decision-making. The course focuses on understanding data types, organizing and analyzing qualitative and quantitative data, applying statistical techniques, and interpreting results for engineering and research applications. Emphasis is placed on analytical thinking, statistical reasoning, and the use of software tools for effective data analysis.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the role of data analysis in engineering decision-making and research. (Cognitive Knowledge Level: Understand)
CO 2	Develop an understanding of principles of quantitative and qualitative research methods (Cognitive Knowledge Level: Understand)
CO 3	Develop an understanding of principles of data analysis and interpretation. (Cognitive Knowledge Level: Understand)
CO 4	Apply important qualitative and quantitative statistical techniques for analysing and interpreting research data. (Cognitive Knowledge Level: Apply)
CO 5	Apply basic optimization concepts and software tools for coding and analyzing data (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	1	1	1	1	–	1	–	1
CO2	3	3	1	2	1	–	–	–	1	–	2
CO3	2	3	2	3	3	1	–	1	1	–	2
CO4	2	3	2	3	3		1	1	1	1	2
CO5	2	3	3	3	3	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	30
Understand	60	40	40
Apply		40	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Data Analysis for Decision Making (6 hours)

Introduction to data analysis – role of data analytics in engineering decisions – levels of data analysis – data analysis framework – principles and benefits – data types – measures of central tendency and dispersion – skewness and kurtosis – box plot – sampling variation – central limit theorem.

Module 2: Data Types and Data Organization (8 hours)

Data categorization – qualitative and quantitative data – discrete and continuous data – scales of measurement – organization and analysis of qualitative data – coding and classification – approaches to qualitative data analysis – organization and presentation of quantitative data – tabulation and graphical representation.

Module 3: Statistical Foundations for Engineering Analysis (8 hours)

Descriptive statistics and probability concepts – scatter diagram – sampling and types of sampling – probability distributions (introductory concepts) – inferential statistics – standard errors – confidence limits – hypothesis testing – Type I and Type II errors – correlation and regression analysis with engineering applications.

Module 4: Univariate and Bivariate Analysis (7 hours)

Parametric tests – t-test – F-test – analysis of variance (ANOVA).

Non-parametric tests – Chi-square test – Mann–Whitney U test – Median test – goodness-of-fit tests – selection and interpretation of statistical tests in engineering contexts.

Module 5: Data Analytics Tools and Data Preprocessing (7 hours)

Overview of data analysis tools – Excel, SPSS, Python (introductory level) – coding and data entry – data analytics life cycle – data preprocessing – data cleaning – handling missing data – data normalization and transformation.

Text Books

1. Douglas C. Montgomery & George C. Runger, *Applied Statistics and Probability for Engineers*, 7th Edition, Wiley.
2. Anil Maheshwari, *Data Analytics*, 1st Edition, McGraw Hill Education.

Reference Books

1. Gareth James, Daniela Witten, Trevor Hastie & Robert Tibshirani, *An Introduction to Statistical Learning: With Applications in R*, 2nd Edition, Springer.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1: Data Analysis for Decision Making	**7**
1.1	Introduction to data analysis; role of data analytics in decision-making	2
1.2	Levels of data analysis; data analysis framework; principles and benefits of data analysis;	2
1.3	Data types; measures of central tendency and dispersion;	1
1.4	Skewness and kurtosis;	1
1.5	Box plot; sampling variation; central limit theorem.	1
	Module 2: Data Types and Data Organization	**7**
2.1	Data categorization; qualitative and quantitative data;	1
2.2	Organization and analysis of qualitative data;	1
2.3	Approaches to qualitative data analysis;	2
2.4	Organization and presentation of quantitative data.	1
2.5	Data categorization; qualitative and quantitative data;	2
	Module 3: Statistical Foundations for Engineering Analysis	**8**
3.1	Descriptive statistics and probability	1
3.2	Scatter diagram; sampling and types of sampling	1
3.3	Probability distributions; inferential statistics; standard errors	2
3.4	Confidence limits	1
3.5	Hypothesis testing	1
3.6	Type I and Type II errors	1
3.7	Correlation and regression analysis.	1
	Module 4: Univariate and Bivariate Analysis	**7**
4.1	t-test	1
4.2	F-test	2
4.3	ANOVA	1
4.4	Chi-square test	1
4.5	Mann–Whitney U test	1
4.6	Median test	1
4.7	Goodness-of-fit tests.	
	Module 5: Data Analytics Tools and Data Preprocessing	**7**
5.1	Overview of software for data analysis	1
5.2	Coding and data entry using Excel, SPSS, and Python	2
5.3	Data analytics life cycle	1
5.4	Data preprocessing	1
5.5	Data cleaning	1
5.6	Data normalization.	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the role of data analysis in engineering decision-making.
2. Describe the levels of data analysis with suitable examples.
3. Explain measures of central tendency and dispersion used in data analysis.
4. Discuss sampling variation and the significance of the Central Limit Theorem.

Course Outcome 2 (CO2):

1. Differentiate between qualitative and quantitative data with examples.
2. Explain the organization and analysis of qualitative data.
3. Describe methods for organizing and presenting quantitative data.
4. Discuss approaches to qualitative data analysis in research studies.

Course Outcome 3 (CO3):

1. Explain the concepts of hypothesis testing and Type I and Type II errors.
2. Describe correlation and regression analysis and their applications.
3. Explain different types of sampling methods used in data analysis.
4. Discuss probability distributions and their importance in statistical analysis.

Course Outcome 4 (CO4):

1. Explain the t-test and its applications in engineering analysis.
2. Describe ANOVA and its role in comparing multiple data sets.
3. Explain the chi-square test and goodness-of-fit test with examples.
4. Differentiate between parametric and non-parametric tests.

Course Outcome 5 (CO5)

1. Explain the data analytics life cycle with suitable examples.
2. Describe data preprocessing, data cleaning, and normalization techniques.
3. Discuss the role of software tools such as Excel, SPSS, and Python in data analysis.
4. Explain the importance of optimization techniques in data-driven engineering applications.

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: **B24ME3G17**

Course Name: **FUNDAMENTALS OF DATA ANALYSIS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 What is the role of data analysis in engineering decision-making?

2 What is the Central Limit Theorem and why is it important in data analysis?

3 Differentiate between qualitative and quantitative data.

4 What are the common methods used for presenting quantitative data?

5 What is hypothesis testing?

6 What is the difference between correlation and regression analysis?

7 What is a t-test?

8 What is the purpose of the chi-square test?

9 What is data preprocessing in the data analytics life cycle?

10 Name any two software tools used for data analysis and state one application of each.

PART B

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

Module 1

11 Explain the role of data analysis in engineering decision-making. Discuss the different levels of data analysis with suitable examples. (14 marks)

OR

12 Describe measures of central tendency and dispersion. Explain the significance of sampling variation and the Central Limit Theorem in data analysis. 14 marks)

Module 2

13 Explain the nature of qualitative and quantitative data. Discuss methods for organizing and analyzing qualitative data in research. (14 marks)

OR

14 Describe the organization and presentation of quantitative data using appropriate techniques and examples. (14 marks)

Module 3

15 Explain the fundamentals of descriptive and inferential statistics. Discuss hypothesis testing, confidence limits, and Type I and Type II errors. (14 marks)

OR

16 Describe correlation and regression analysis and explain their importance in engineering applications. (14 marks)

Module 4

17 Explain parametric and non-parametric tests used in univariate and bivariate analysis. Discuss the t-test, ANOVA, and chi-square test with examples. (14 marks)

OR

18 Describe the Mann–Whitney U test, median test, and goodness-of-fit test, highlighting their applications. (14 marks)

Module 5

19 Explain the data analytics life cycle in detail. Discuss the steps involved in data preprocessing, cleaning, and normalization. (14 marks)

OR

20 Discuss the role of optimization techniques and software tools such as Excel, SPSS, and Python in engineering data analysis. (14 marks)

B24ME3L08	THERMAL SYSTEMS LAB	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

The Thermal Systems Laboratory offers hands-on experience in heat transfer and thermal system operations. It focuses on experimental validation of conduction, convection, and radiation, along with performance analysis of heat exchangers, refrigeration, and air-conditioning systems. The course also includes calibration and dynamic study of thermal sensors, bridging theoretical concepts with industrial applications.

Prerequisite

Nil

Course Outcomes

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

CO 1	Apply the principles of conduction, convection, and radiation to analyze experimental heat transfer behavior. (Cognitive Knowledge Level: Apply)
CO 2	Analyze the calibration characteristics and accuracy of temperature and pressure measuring instruments using experimental data. (Cognitive Knowledge Level: Analyze)
CO 3	Evaluate the thermal performance of various heat exchangers under different flow arrangements and operating conditions. (Cognitive Knowledge Level: Evaluate)
CO 4	Determine the performance parameters of refrigeration systems through experiments. (Cognitive Knowledge Level: Apply)
CO 5	Analyze cooling performance and determine psychrometric properties in air-conditioning experiments. (Cognitive Knowledge Level: Analyze)

Mapping of Course Outcomes with Program Outcomes

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

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Evaluation
- Class work/ Assessment : 10 marks
- Viva (Self Study) : 10 marks

Viva voce / test : 15 marks
Record : 5 marks

End Semester Examination Pattern

Experiment part : 70 marks
Viva voce : 30 marks

Guidelines for award of marks for the experiment part:

Preliminary work : 15 Marks
Implementing the work/Conducting the experiment : 25 Marks
Performance, result and inference : 30 Marks

KNOWLEDGE IS POWER

SYLLABUS

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LIST OF EXPERIMENTS

Minimum **12** experiments are mandatory (Including study)

1	Determination of Heat Transfer Coefficient in Forced Convection
2	Determination on Natural Convection Heat Transfer from a Vertical Surface
3	Performance Evaluation of a Parallel Flow Heat Exchanger
4	Performance Evaluation of Counter Flow Heat Exchangers
5	Determination of Thermal Conductivity and Thermal Resistance of a Composite Wall
6	Verification of Stefan–Boltzmann Law for Thermal Radiation
7	Determination of Emissivity of Various Surfaces
8	Calibration of Resistance Temperature Detector (RTD)
9	Calibration of Thermocouple
10	Determination of Critical Heat Flux in Pool Boiling
11	Performance Test on Vapour Compression Refrigeration System
12	Performance Evaluation of Air Conditioning System using Psychrometric Analysis
13	Determination of Heat flow rate and Thermal Conductivity of a lagged pipe.
14	Calibration of Pressure Gauges.

Reference Books

1. Çengel, Y. A., and Ghajar, A. J., Heat and Mass Transfer: Fundamentals and Applications; McGraw-Hill.
2. Lienhard, J. H. V., and Lienhard, J. H. IV., A Heat Transfer Textbook; Phlogiston Press.
3. Martin, R. J., Thermal Systems Design: Fundamentals and Projects; Wiley.
4. Modest, M. F., Radiative Heat Transfer; Academic Press.
5. ASHRAE, ASHRAE Handbook – HVAC Systems and Equipment; ASHRAE, 2024 Edn.

B24ME3L09	COMPUTER AIDED DESIGN AND ANALYSIS LAB	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

This course introduces students to modern digital tools for mechanical design and simulation. It helps them develop skills in 3D modeling, drafting, and computational analysis using CAD and CAE software. Students learn to model components, perform structural and thermal analyses, and interpret results effectively. The lab connects theoretical design concepts with real-world engineering applications. It enhances creativity and analytical ability in problem-solving. By the end of the course, students can design and analyze mechanical systems efficiently using computer-aided methods.

Prerequisite

Nil

Course Outcomes

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

CO 1	Understand the fundamentals of computer-aided design and modeling procedures using modern CAD tools. (Cognitive Knowledge Level: Understand)
CO 2	Develop solid models of mechanical components using parametric modeling techniques. (Cognitive Knowledge Level: Apply)
CO 3	Assemble machine elements and generate detailed engineering drawings using advanced CAD software. (Cognitive Knowledge Level: Apply)
CO 4	Analyze the structural, thermal, and modal behavior of components by applying Finite Element Analysis techniques. (Cognitive Knowledge Level: Analyze)
CO 5	Evaluate and interpret results of structural, thermal, fluid flow, and modal analyses using standard CAE tools for engineering problem-solving. (Cognitive Knowledge Level: Evaluate)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	1	1	3					2		1
CO 2	3	2	2	1	3					2		1
CO 3	3	2	2	1	3					2		1
CO 4	3	3	3	3	3					2		1
CO 5	3	3	3	3	3					2		1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	10	10	10
Understand	30	30	30
Apply	30	30	30
Analyse	30	30	30
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Evaluation

- Class work/ Assessment : 10 marks
- Viva (Self Study) : 10 marks

Test / Viva-voce : 15 marks
Record : 5 marks

End Semester Examination Pattern

End semester examination shall cover the entire syllabus, focusing on modelling and analysis. There will be two parts, Part A and Part B. Part A contains question from Assembly and Modelling part; Part B contains question from Analysis part. The following general guidelines should be maintained for the award of marks.

Part A Modelling & Assembly – 35 marks
Part B Analysis – 35 marks
Viva voce – 30 marks

SYLLABUS

LIST OF EXPERIMENTS

Minimum **12** experiments are mandatory (Including study)

1	Introduction to CAD software (Creo)
2	Part modeling of cotter and spigot
3	Assembly of a cotter joint
4	Assembly of a knuckle joint
5	Assembly of a flanged coupling
6	Assembly of a plummer block
7	Assembly of a screw jack
8	Assembly of a connecting rod mechanism.
9	Introduction to FEA & FE software (Ansys)
10	Perform a structural analysis of a truss. (Structural)
11	Stress and deflection analysis of a cantilever beam. (Structural)
12	Perform the structural analysis of a plate with a hole under tension. (Structural)
13	Perform modal analysis of a cantilever beam. (Structural)
14	Perform steady-state analysis of heat conduction through a plane wall. (Thermal)
15	Perform a transient heat transfer analysis of a solid fin. (Thermal)
16	Perform analysis of fully developed laminar/turbulent flow through a circular pipe. (Fluid flow) /

Reference Books

1. Sham Tickoo (CADCIM Technologies), Creo Parametric 9.0 for Designers, CADCIM Technologies, ISBN 1640571639.
2. Jayant Sarkar, Computer Aided Design: A Conceptual Approach, CRC Press.
3. Reddy, J. N. Introduction to the finite element method (4th ed.). McGraw-Hill Education.
4. Lee, H. H. Finite element simulations with ANSYS Workbench 2023: Theory, applications, case studies (1st ed.). SDC Publications.

MAR ATHANASIUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution
Kothamangalam, Kerala, India

B.TECH MECHANICAL ENGINEERING

SEMESTER 6

(MINOR)

SYLLABUS

B24MEM61	MACHINE DESIGN	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course introduces students from other engineering disciplines to the essential principles, methodologies, and analytical frameworks of mechanical design. It emphasises the role of design in real-world product development, the importance of dimensional control, tolerance systems, and standardised fits, all essential for manufacturing accuracy and interchangeability. Students will gain an understanding of common failure modes, theories of failure, and the significance of stress concentration in engineering components. The course also covers the design and analysis of frequently used machine elements such as detachable joints, couplings, and pressure vessels. By the end of the course, learners will be able to interpret design requirements, apply fundamental design principles, and evaluate the performance and safety of basic machine components, thereby strengthening their interdisciplinary engineering competence.

Prerequisite

B24MEM51 - DYNAMICS OF MACHINES

Course Outcomes

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

CO 1	Apply principles of dimensional control, tolerances, and ISO fit systems to specify manufacturable component dimensions. (Cognitive Knowledge Level: Apply)
CO 2	Apply failure theories to determine the safety of mechanical components under given loading conditions. (Cognitive Knowledge Level: Apply)
CO 3	Apply design principles of detachable joints to determine their suitability for given engineering applications. (Cognitive Knowledge Level: Apply)
CO 4	Apply coupling selection and design principles to determine suitable mechanical couplings for specified functional requirements. (Cognitive Knowledge Level: Apply)
CO 5	Apply stress equations and relevant design codes to determine dimensions of thin and thick pressure vessels. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	3	3	2		1			1			1
CO 2	3	3	2					1			1
CO 3	3	3	3		1			1			1
CO 4	3	3	3		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	10	10	10
Understand	40	40	40
Apply	50	50	50
Analyse			
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 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), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module, of which the student should answer any one. Each question can have a maximum of 2 subdivisions and carry 14 marks.

KNOWLEDGE IS POWER

SYLLABUS

MODULE 1: Design Fundamentals, Limits, and Fits (10 hours)

Role of design in product development, Stages of design, Design considerations, Introduction to dimensional control, Tolerances- Unilateral and Bilateral, Fits- types of fits, Standard systems of fits, Hole-basis system, Shaft-basis system, ISO system of limits and fits.

MODULE 2: Failure Theories and Design Standards (10 hours)

Introduction to failure in engineering design, Modes of failure: yielding, fracture, fatigue, creep, buckling, Theories of failure- Maximum principal stress theory, Maximum shear stress theory, Maximum principal strain theory, Maximum strain energy theory, Maximum distortion energy theory, Use of standards in design, Common international and national standards, Stress concentration, Causes of stress concentration.

MODULE 3: Design of Detachable Joints (8 hours)

Introduction to detachable joints, Advantages, limitations, and common applications, Types of detachable joints- Threaded fasteners, Keys, cotters, pins, Knuckle joints, universal joints, Types of cotter joints, Design considerations for cotter joints, Design of socket and spigot cotter joint, Design of knuckle joint.

MODULE 4: Design of Couplings (8 hours)

Introduction to couplings, Classification of Couplings- Rigid couplings, Flexible couplings, Fluid couplings, Requirements of a good coupling, Design of sleeve coupling, Design of split muff coupling, Design of flange coupling.

MODULE 5: Design of Pressure Vessels (9 hours)

Pressure vessels - concept and applications, Classification of pressure vessels, Stresses in pressure vessels, Design of thin cylindrical pressure vessels, Design of thin spherical shells, Design of thick cylindrical pressure vessels, Standards & codes for pressure vessel design.

Design Data Books (permitted for reference in the university examination)

1. Mahadevan K. and K. Balaveera Reddy, *Design Data Handbook, Mechanical Engineers in SI and Metric Units*, CBS Publishers & Distributors.
2. K. Lingaiah, *Machine Design Data Book*, McGraw Hill Education.
3. PSG Design Data - *Data Book of Engineers*, Kalaikathir Achchangam, 2024.

Text Books

1. Norton, R. L., *Machine design: An integrated approach,* Pearson Education.
2. Spotts M.F., Shoup T.E., & Hornberger L.E., *Design of machine elements* Pearson Edn.
3. Bhandari, V. B., *Design of machine elements*. McGraw-Hill Education.

Reference Books

1. Budynas R.G. & Nisbett J.K. *Shigley's mechanical engineering design,* McGraw-Hill.
2. Mott R.L., Vavrek T., & Wang, J., *Machine design: An introduction* Pearson Education.
3. Juvinall R. C., & Marshek K. M., *Fundamentals of machine component design*. Wiley.
4. Ugural A. C., *Mechanical design of machine components* CRC Press.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module1	**10**
1.1	Role of design in product development	1
1.2	Stages of design, Design considerations	2
1.3	Introduction to dimensional control	1
1.4	Tolerances- Unilateral and Bilateral	1
1.5	Fits- type of fits, Standard systems of fits	2
1.6	Hole-basis system, Shaft-basis system	2
1.7	ISO system of limits and fits.	1
	Module 2	**10**
2.1	Introduction to failure in engineering design	1
2.2	Modes of failure: yielding, fracture, fatigue, creep, buckling	2
2.3	Theories of failure- Maximum principal stress theory	1
2.4	Maximum shear stress theory, Maximum principal strain theory	1
2.5	Maximum strain energy theory, Maximum distortion energy theory	1
2.6	Use of standards in design, Common international and national standards	1
2.7	Stress concentration	2
2.8	Causes of stress concentration	1
	Module 3	**8**
3.1	Introduction to detachable joints, Advantages, limitations, and common applications	1
3.2	Types of detachable joints- Threaded fasteners, Keys, cotters, pins, Knuckle joints, universal joints, Types of cotter joints	2
3.3	Design considerations for cotter joints	1
3.4	Design of socket and spigot cotter joint	2
3.5	Design of knuckle joint	2
	Module 4	**8**
4.1	Introduction to couplings, Classification of Couplings- Rigid couplings, Flexible couplings, Fluid couplings	1
4.2	Requirements of a good coupling	1
4.3	Design of sleeve coupling	2
4.4	Design of split muff coupling	2
4.5	Design of flange coupling	2

	Module 5	**9**
5.1	Pressure vessels- concept and applications	1
5.2	Classification of pressure vessels, Stresses in pressure vessels	1
5.3	Design of thin cylindrical pressure vessels	2
5.4	Design of thin spherical shells	2
5.5	Design of thick cylindrical pressure vessels	2
5.6	Standards & codes for pressure vessel design	1
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Describe the ISO system of limits and fits.
2. Explain the hole basis and shaft basis system.
3. A shaft is manufactured within the specified limits of 30.03 and 29.97 mm. Find the high and low limits of the bush to give a maximum clearance of 0.15 mm and a minimum clearance of 0.02 mm.

Course Outcome 2 (CO2):

1. A solid circular shaft is subjected to an axial tensile stress of 80 MPa and a torsional shear stress of 50 MPa. Using the maximum shear stress theory and the maximum distortion energy theory, analyse whether the shaft is safe if the material has a yield strength of 250 MPa.
2. A square steel plate of width W=200 mm, thickness t=10 mm, has a central circular hole of diameter d=40 mm. The plate is pulled in tension by an axial force P = 50 kN. For this geometry, the theoretical stress-concentration factor at the edge of the hole may be taken as K_t=3.0. The steel has a yield strength of σ_Y=250 MPa.
    a. Calculate the nominal tensile stress in the plate.
    b. Calculate the maximum local stress at the hole due to stress concentration.
    c. Determine the factor of safety against yielding based on maximum local stress.
3. Discuss in detail the various modes of failure that occur in mechanical components subjected to different types of loading. Also cite with suitable examples, the design strategies used to prevent these failures.

Course Outcome 3 (CO3):

1. Design a socket and spigot cotter joint to transmit an axial tensile load P=60 kN. Use the following allowable stresses for the material:
   Allowable tensile stress in the rod and spigot: σ_{allow}=80 MPa
   Allowable shear stress for cotter: τ_{allow}=50 MPa
   Allowable crushing (bearing) stress: σ_{crush}=200 MPa

   Calculate the diameter of the rod and suitable dimensions for the cotter, spigot and socket.
2. Design a knuckle joint to connect two coaxial rods which are subjected to an axial tensile force of 75 kN. Design the joint and specify the dimensions of its components.

Select suitable materials for the parts.

3. Explain in detail the different types of detachable joints.

Course Outcome 4 (CO4):

1. What are the design requirements of a good coupling?
2. Design a rigid CI flange coupling to transmit 20kW of power at 1440 rpm. The allowable shear stress for the flange is 4 MPa. The shafts, keys and bolts are made of annealed steel having an allowable shear stress of 90 MPa. Allowable crushing stress for key = 180 MPa.
3. Design a muff coupling to connect two steel shafts transmitting 30 kW of power at 300 rpm. Shafts and keys are made up of Plain carbon steel 30C8 ($S_{yt} = S_{yc} = 400$ N/mm²). The sleeve is made of FG 200 grey cast iron ($S_ut = 200$ N/mm²). The shafts and key have a safety factor of 4. Based on ultimate strength, the sleeve has a factor of safety of 5.

Course Outcome 5 (CO5):

1. What is the criterion to distinguish between thin and thick cylinders?
2. A hydraulic actuator used in an automated packaging machine must deliver a lifting force of 8 kN. The resistance due to seal friction and guide wear contributes an additional 12% of the lifting force. The working pressure inside the actuator chamber is 12 MPa. The cylinder is made of cast iron FG 200, and the factor of safety is 5. Determine the diameter and the thickness of the cylinder.
3. What techniques are employed for pre-stressing cylindrical pressure vessels?

KNOWLEDGE IS POWER

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SIXTH SEMESTER MINOR DEGREE EXAMINATION, MAY 2027
Course Code: **B24MEM61**

Course Name: **MACHINE DESIGN**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the concept of standardisation in engineering.
2. Differentiate between the hole basis system and the shaft basis system and explain which system is most preferred?
3. Differentiate between fatigue failure and creep failure in mechanical components.
4. Discuss different methods to reduce stress concentration.
5. What are the advantages of a knuckle joint?
6. Discuss the types of threads used for fastening and their features.
7. Explain the differences between rigid and flexible couplings.
8. List any three practical applications of a fluid coupling.
9. Explain the criterion to distinguish between thin and thick cylinders.
10. What are the types of end closure for cylindrical pressure vessels?

PART B

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

Module 1

11) Describe the various stages involved in the design of a mechanical component. Analyse the key design considerations that influence each stage. (14 marks)

OR

12) A gear shaft used in an industrial conveyor system is manufactured within the size limits of 45.06 mm and 44.94 mm. Determine the maximum and minimum limits of the mating bearing bush so as to obtain a minimum clearance of 0.03 mm and a maximum clearance of 0.18 mm between the shaft and the bush. (14 marks)

Module 2

13) At a point in a ductile steel component used in a power transmission shaft, the principal stresses are 120 N/mm² (tensile), 40 N/mm² (tensile), and 60 N/mm² (compressive). The elastic limit of the material in simple tension is 150 N/mm², and Poisson's ratio is 0.3. Determine whether failure will occur according to the following failure theories:

a) Maximum Principal Stress Theory

b) Maximum Principal Strain Theory

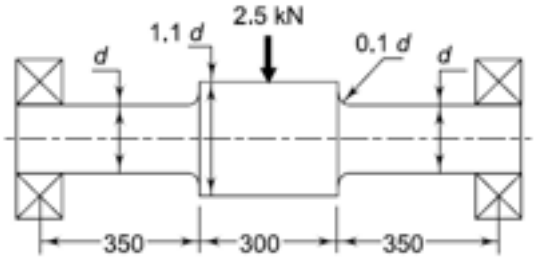
c) Maximum Shear Stress Theory

d) Total Strain Energy Theory

e) Distortion Energy Theory (14 marks)

OR

14) A non-rotating shaft supporting a load of 2.5 kN is shown in the figure. The shaft is made of brittle material, with an ultimate tensile strength of 350 N/mm2. The factor of safety is 4. Determine the dimensions of the shaft. (14 marks)



Module 3

15) Design a cotter joint to connect two steel rods of equal diameter. Each rod is subjected to an axial tensile force of 100 kN. Design the joint and specify its main dimensions. (14 marks)

OR

16) Design a knuckle joint used to connect two tension members in a crane tie-rod mechanism, subjected to an axial tensile load of 200 kN. Determine the required dimensions of the knuckle joint and recommend suitable materials for each part of the joint. (14 marks)

Module 4

17) A rigid flange coupling is employed to transmit power from a 60 kW electric motor running at 1500 rpm to a reciprocating pump. The starting torque of the motor is 200% of the rated torque. The coupling uses 8 bolts arranged on a pitch circle diameter of 160 mm. The bolts are manufactured from steel 40C8, having a yield strength in tension of 400 N/mm². A factor of safety of 3 is to be used in the design. Assume that the bolts are finger-tight and fitted in reamed and ground holes. Also, take the yield strength in shear as 0.577 times the yield strength in tension. (14 marks)

OR

18) Design a muff (sleeve) coupling to join two steel shafts transmitting 35 kW of power at a speed of 300 rpm. The shafts and key are made of plain carbon steel 40C8, having

yield strength in tension and compression of 380 N/mm². The sleeve is made of grey cast iron FG 260 with an ultimate tensile strength of 260 N/mm². Use a factor of safety of 3.5 for the shaft and key, and a factor of safety of 5 for the sleeve, based on its ultimate strength. Design the muff coupling and determine the principal dimensions of the shaft and the sleeve. (14 marks)

Module 5

19) A thin cylindrical pressure vessel is designed to store compressed gas at an internal pressure of 3.5 MPa. The internal diameter of the cylinder is 1.2 m. The vessel is fabricated using steel plates riveted along the longitudinal and circumferential seams. The ultimate tensile strength of the plate material is 410 N/mm². The factor of safety is 4, and the efficiency of the longitudinal joint is 85%. Determine:

a) The required thickness of the cylindrical shell based on hoop stress.

b) The thickness of the shell based on longitudinal stress

c) The safe thickness to be adopted for the pressure vessel. (14 marks)

OR

20) A thick cylindrical pressure vessel is required to withstand an internal pressure of 80 MPa. The internal diameter of the cylinder is 150 mm. The material of the cylinder has a yield strength in tension of 400 N/mm². Using the maximum principal stress theory with a factor of safety of 2.5, determine the required outer diameter of the cylinder. Assume that the external pressure is negligible. (14 marks)

KNOWLEDGE IS POWER

B24MEM62	HEAT TRANSFER	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course introduces the principles of heat transfer through conduction, convection, and radiation. It develops analytical skills required to evaluate and design thermal systems in buildings, mechanical equipment, electrical machines, and electronic devices. The course equips students to apply heat transfer concepts to real-world engineering problems with emphasis on energy efficiency and modern thermal management technologies.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand conduction principles and thermal resistance concepts to analyze heat transfer in plane, cylindrical, and spherical systems. (Cognitive Knowledge Level: Understand)
CO 2	Understand heat transfer enhancement using fins by evaluating fin equations, performance parameters, and applications. (Cognitive Knowledge Level: Understand)
CO 3	Apply heat transfer mechanisms in buildings to determine insulation requirements, thermal comfort conditions, and energy-efficient designs. (Cognitive Knowledge Level: Apply)
CO 4	Apply forced and natural convection principles with empirical correlations to estimate cooling requirements of electrical machines. (Cognitive Knowledge Level: Apply)
CO 5	Apply radiation laws, heat exchanger fundamentals, and electronic cooling techniques to solve thermal management problems. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	10	10
Understand	60	30	30
Apply		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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Fundamentals of Heat Conduction (10 hours)

Introduction to modes of heat transfer: Conduction, Convection, and Radiation. Comparison of heat transfer with thermodynamics. Fourier's law of heat conduction; thermal conductivity and its physical meaning. Derivation of the General Heat Conduction Equation in Cartesian coordinates.1D steady-state conduction with and without heat generation: Plane walls, composite walls, thermal contact resistance, thermal resistance networks. (equation only). Cylindrical and spherical systems: Single and composite walls, critical radius of insulation. (without derivation). Thermal Insulators: engineering applications.

MODULE 2: Extended Surfaces and Engineering Applications (9 hours)

Extended surfaces (Fins): Engineering relevance in radiators, compressors, motor housings, and condensers. Types and geometries of fins; derivation of fin equation and boundary conditions. Fin performance parameters: Temperature distribution, fin efficiency, fin effectiveness, and insulated-tip fins. Applications of heat transfer in mechanical engineering systems — heat exchangers, engines, turbines, refrigeration, and HVAC.

MODULE 3: Heat Transfer in Buildings and Civil Systems (9 hours)

Role of heat transfer in civil engineering: Building insulation, passive cooling, thermal comfort, and material selection. Conduction through composite walls and roofs; steady-state and transient thermal response of structures. Convection in building ventilation: Natural convection currents, air stratification, stack effect. Solar radiation and heat gain through glass; introduction to radiative properties of building materials. Thermal Insulation in buildings. Application examples: Energy-efficient buildings, green roofs, and thermal energy storage in construction materials.

MODULE 4: Heat Transfer in Electrical Machines and Power Systems (8 hours)

Importance of heat transfer in electrical machines and power systems. Forced convection in internal flows: Cooling of transformers, generators, and windings, air and oil circulation. Natural convection cooling of electrical panels, heat sinks, and enclosures. Empirical correlations for convection from horizontal and vertical plates, cylinders, and finned surfaces used in electrical systems. Heat dissipation in buried and air-laid cables.

MODULE 5: Radiation, Heat Exchangers, and Electronic Cooling (9 hours)

Thermal radiation fundamentals, laws of radiation: Blackbody, grey body, emissivity, absorptivity, reflectivity, transmissivity. Radiation view factors and heat exchange between surfaces in electronic enclosures. Heat exchangers and compact cooling systems: Types, LMTD concept, overall heat transfer coefficient, fouling factor. Cooling techniques for electronic devices: Air cooling, liquid cooling, thermoelectric cooling, and heat pipes. PCM, chip cooling systems. Case studies: Data centers, LED lighting systems, and EV battery thermal management (thermal runaway).

Text Books

1. Rajput, R. K., *Heat and Mass Transfer*, S. Chand & Company Ltd., New Delhi.
2. Sukhatme, S. P., *A Textbook of Heat Transfer*, Universities Press, Hyderabad.
3. Kodandaraman, V. D., *Fundamentals of Heat and Mass Transfer*, PHI Learning.
4. Nag, P. K., *Heat and Mass Transfer*, Tata McGraw-Hill Education, New Delhi.

Reference Books

1. Çengel, Y. A., *Heat and Mass Transfer: A Practical Approach*, McGraw-Hill Education.
2. Incropera, F. P., and DeWitt, D. P., *Fundamentals of Heat and Mass Transfer*, Wiley.
3. Kothandaraman, C. P., and Subramanyan, S., *Heat and Mass Transfer Data Book*, New Age International Publishers.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**10**
1.1	Introduction to modes of heat transfer: Conduction, Convection, and Radiation. Comparison of heat transfer with thermodynamics. Fourier's law of heat conduction; thermal conductivity and its physical meaning.	3
1.2	Derivation of the General Heat Conduction Equation in Cartesian coordinates.1D steady-state conduction with and without heat generation: Plane walls, composite walls, thermal contact resistance, thermal resistance networks. (equation only)	3
1.3	Cylindrical and spherical systems: Single and composite walls, critical radius of insulation. (without derivation).simple problems.	3
1.4	Thermal Insulators: engineering applications.	1
	Module 2	**9**
2.1	Extended surfaces (Fins): Engineering relevance in radiators, compressors, motor housings, and condensers.	2
2.2	Types and geometries of fins; derivation of fin equation and boundary conditions.	2
2.3	Fin performance parameters: Temperature distribution, fin efficiency, fin effectiveness, and insulated-tip fins.	2
2.4	Applications of heat transfer in mechanical engineering systems — heat exchangers, engines, turbines, refrigeration, and HVAC.	3
	Module 3	**9**
3.1	Role of heat transfer in civil engineering: Building insulation, passive cooling, thermal comfort, and material selection.	2

3.2	Conduction through composite walls and roofs; steady-state and transient thermal response of structures.	2
3.3	Convection in building ventilation: Natural convection currents, air stratification, stack effect.	1
3.4	Solar radiation and heat gain through glass; introduction to radiative properties of building materials. Thermal Insulation in buildings.	2
3.5	Application examples: Energy-efficient buildings, green roofs, and thermal energy storage in construction materials.	2
	Module 4	**8**
4.1	Importance of heat transfer in electrical machines and power systems.	2
4.2	Forced convection in internal flows: Cooling of transformers, generators, and windings, air and oil circulation.	2
4.3	Natural convection cooling of electrical panels, heat sinks, and enclosures.	2
4.4	Empirical correlations for convection from horizontal and vertical plates, cylinders, and finned surfaces used in electrical systems. Heat dissipation in buried and air-laid cables.	2
	Module 5	**9**
5.1	Thermal radiation fundamentals, laws of radiation: Blackbody, grey body, emissivity, absorptivity, reflectivity, transmissivity.	2
5.2	Radiation view factors and heat exchange between surfaces in electronic enclosures.	1
5.3	Heat exchangers and compact cooling systems: Types, LMTD concept, overall heat transfer coefficient, fouling factor.	2
5.4	Cooling techniques for electronic devices: Air cooling, liquid cooling, thermoelectric cooling, and heat pipes. PCM, chip cooling systems.	2
5.5	Case studies: Data centers, LED lighting systems, and EV battery thermal management (thermal runaway).	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. A composite wall consists of three layers in series:
   - Layer 1: k_1 = 0.8 W/mK, thickness = 0.04 m
   - Layer 2: k_2 = 0.3 W/mK, thickness = 0.02 m
   - Layer 3: k_3 = 1.2 W/mK, thickness = 0.03 m

   The inner and outer surface temperatures are 150°C and 25°C.
   Determine:
   (a) Overall thermal resistance
   (b) Heat transfer rate (per m² area)
   (c) Interface temperatures between layers.

2. Derive the general 3D heat conduction equation in Cartesian coordinates.
3. Explain steady vs unsteady heat conduction and thermal resistance networks for composite plane walls.

Course Outcome 2 (CO2):

1. Describe types and geometries of fins. . Discuss the role of fins in HVAC equipments.
2. Derive the differential fin equation for a straight fin with uniform cross-section and constant thermal conductivity

Course Outcome 3 (CO3):

1. Explain conduction through composite building walls and roofs. Discuss steady-state and transient heat transfer in buildings and how material selection affects thermal comfort.
2. Describe natural convection currents in buildings. Explain the concepts of air stratification and the stack effect, and their roles in ventilation and passive cooling.

Course Outcome 4 (CO4):

1. Discuss temperature rise, insulation degradation, and cooling requirements for transformers, motors, and generators.
2. Describe forced convection cooling using air and oil circulation in transformers, generators, and windings. Explain how flow arrangements influence cooling performance.

Course Outcome 5 (CO5)

1. Discuss cooling techniques for electronic systems—air cooling, liquid cooling, heat pipes, thermoelectric cooling, and PCM.
2. Describe view factors and radiation heat exchange inside electronic enclosures. Explain how enclosure geometry and surface properties affect radiative cooling.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SIXTH SEMESTER B TECH DEGREE EXAMINATION, MAY 2027

Course Code: **B24MEM62**

Course Name: **HEAT TRANSFER**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1		Differentiate between conduction, convection, and radiation with one practical engineering example for each mode.
2		Explain thermal contact resistance. Why does it occur, and how does it affect heat transfer in composite walls?
3		Explain why fin effectiveness is important in fin design.
4		State the engineering relevance of fins in radiators, compressors, and condensers.
5		Define thermal insulation in buildings. List any two commonly used insulating materials and briefly explain their importance.
6		What is passive cooling? Explain how it helps to reduce energy consumption in building designs.
7		Why is heat dissipation critical in buried and air-laid power cables? Mention any two factors that influence the thermal performance of underground cables.
8		What is the function of heat sinks in electrical systems? Briefly explain how natural convection enhances their cooling performance.
9		What is the importance of heat pipes in electronic cooling? Mention two advantages that make them suitable for compact electronic devices..
10		Define thermal runaway in EV battery systems. Briefly explain why effective thermal management is essential for preventing it.

PART B

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

Module 1

11	a.	A plane wall of thickness 0.15 m and thermal conductivity k = 1.5 W/m·K has steady-state 1D conduction. The temperatures at the two sides are T_1 = 180°C and

T_2 = 90°C. Write the 1D steady-state conduction equation without heat generation. Calculate the heat transfer rate per unit area (heat flux). (7 marks)

b. Explain the physical meaning of Fourier's law of heat conduction and describe how it is applied to analyze heat transfer through plane and composite walls. (7 marks)

OR

12 Define the critical radius of insulation for a cylindrical system.
A wire of radius 3 mm is insulated using material with k = 0.12 W/m·K and external heat-transfer coefficient h = 10 W/m²·K.
(i) Determine the critical radius.
(ii) State whether adding insulation will increase or decrease heat loss for this wire. (14 marks)

Module 2

13 a. A steel fin (k = 50 W/mK) of length 40 mm and cross-sectional area 25 mm² is attached to a surface at 120°C. The surrounding temperature is 25°C, and heat transfer coefficient is 30 W/m²K.
Find:
(a) Temperature at mid-length of the fin
(b) Heat dissipation from the fin
Assume insulated fin tip. (7 Marks)

b. Discuss the concept of critical radius of insulation for cylindrical systems and explain how thermal conductivity and convection coefficient influence heat loss behavior. (7 marks)

OR

14 a. A straight fin of length 50 mm, thickness 3 mm, and width 50 mm is attached to a surface maintained at 150°C. The ambient air temperature is 25°C, heat transfer coefficient is 40 W/m²·K, and thermal conductivity of the fin material is 200 W/m·K.
Determine:
(a)the temperature at the mid-length of the fin, and
(b) the heat transfer rate from the fin.
Assume the fin tip is insulated. (7 Marks)

b. Explain the concepts of fin efficiency, fin effectiveness, and temperature distribution along the fin. (7 marks)

Module 3

15 a. Explain the role of heat transfer in civil engineering applications such as building insulation, passive cooling, thermal comfort, and material selection. (7 marks)

b. Derive the overall thermal resistance for a multi-layer wall and explain how material arrangement affects steady-state and transient thermal behaviour of structures. (7 marks)

OR

16 a. Explain the concepts of natural convection currents, air stratification, and the stack effect, and their importance in achieving thermal comfort and indoor air quality. (7 marks)

b. Describe radiative properties of common building materials and discuss how these

concepts are used in designing energy-efficient buildings, green roofs, and thermal energy storage systems. (7 marks)

Module 4

17 a. Explain the importance of heat transfer in electrical machines and power systems. Discuss how temperature rise affects the performance, efficiency, insulation life, and reliability of electrical systems. (7 marks)

b. Describe the role of forced convection cooling in internal flows in electrical machines. Explain how air and oil circulation is used for cooling transformers and generators. (7 marks)

OR

18 a. Explain how buoyancy forces, surface orientation, and geometric design influence natural convection performance and electrical system safety. (7 marks)

b. Explain empirical convection correlations used in electrical systems for estimating heat transfer from horizontal plates, vertical plates, cylinders, and finned surfaces. Illustrate how these correlations are applied in the design of cooling arrangements for transformers and heat sinks. (7 marks)

Module 5

19 Explain the fundamentals of thermal radiation. Discuss blackbody and grey body behavior, and define emissivity, absorptivity, reflectivity, and transmissivity. (14 marks)

OR

20 Discuss various cooling techniques for electronic devices, including air cooling, liquid cooling, thermoelectric cooling, heat pipes, and phase change materials (PCM). Explain their applications with examples from data centers, LED lighting systems, and EV battery thermal management (14 marks)

B24MEM63	INTRODUCTION TO OPERATIONS MANAGEMENT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course provides a foundational understanding of industrial processes and operations essential for effective problem-solving in engineering and management contexts. It focuses on the application of operations concepts such as demand forecasting, inventory management, and aggregate planning to real-world scenarios, while also introducing job shop production activities aimed at improving operational efficiency.

Prerequisites

Nil

Course Outcomes

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

CO 1	Describe the role and evolution of operations management and explain its strategic impact on organizational productivity. (Cognitive Knowledge Level: Understand)
CO 2	Calculate demand forecasts and explain measures of forecast accuracy. (Cognitive Knowledge Level: Understand)
CO 3	Apply appropriate inventory models to manage inventory effectively and optimize stock levels. (Cognitive Knowledge Level: Apply)
CO 4	Develop aggregate plans and apply planning systems to support efficient operational decision-making. (Cognitive Knowledge Level: Apply)
CO 5	Plan and schedule job shop production activities by applying modern production system principles to improve operational efficiency. (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	2	2	1	-	1	2	-	2
CO 2	3	2	2	2	2	-	-	2	2	2	2
CO 3	3	3	3	2	2	-	-	2	2	2	2
CO 4	3	3	3	2	2	-	-	2	2	2	2
CO 5	3	3	3	2	2	-	-	2	2	2	2

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	10	10
Understand	60	30	30
Apply		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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Operations Strategy, Facility Location and Layout Planning (9 hours)

Introduction to Operations Management: Role of operations in an organisation, historical evolution and perspectives, operations strategies and productivity in an organisation.

Facility Location and Layout: Factors influencing location planning, factor rating and center of gravity methods of location selection. Types of facility layouts, comparison of layouts. Systematic Layout Planning (SLP), software packages for SLP.

MODULE 2: Demand Forecasting and Forecast Error Analysis (9 hours)

Demand Forecasting: Needs and use of forecasting methods, causal and time series models, moving average, exponential smoothing methods. Trend, cycle, and seasonality components.

Forecasting Errors: Analysis of forecast error, comparison of forecasting methods based on errors.

MODULE 3: Inventory Models and Selective Inventory Control (9 hours)

Inventory Models: Objectives, types of inventories, EOQ and EBQ models for uniform and variable demand with and without shortages, quantity discount models, safety stock.

Selective Inventory Control: ABC analysis, XYZ analysis, VED analysis.

MODULE 4: Aggregate Planning and Production Planning Systems (9 hours)

Aggregate Planning: Definition, value of decision rules, pure and mixed strategies, mathematical models for aggregate planning, transportation method.

Master production schedule: Bill of Material (BOM), MRP - Implementation issues, MRP – II, Introduction to ERP.

MODULE 5: Job Shop Scheduling and Modern Production Systems (9 hours)

Job Shop Production: Activity planning, scheduling, shop loading, sequencing, priority rules for dispatching jobs, Johnson's algorithm.

Modern Production Systems: Introduction to business process re-engineering, lean manufacturing, world-class manufacturing concepts, Just-in-time systems.

Text Books

1. Lee J. Krajewski, Manoj Malhotra, *Operations Management: Processes and Supply Chains*, Pearson Education.
2. William J. Stevenson, *Operations Management*, McGraw-Hill Education.
3. Chary S. N, *Production and Operations Management,* McGraw-Hill.
4. Paneerselvam. R, *Production and Operations Management,* PHI Learning.

Reference Books

1. Jay Heizer, Barry Render, Chuck Munson, *Operations Management: Sustainability*

and Supply Chain Management, Pearson, 14th Edition, 2022.

2. Cecil B. Bozarth, Robert B. Handfield, *Introduction to Operations and Supply Chain Management*, Pearson, 5th Edition, 2019.
3. B. Mahadevan, *Operations Management: Theory and Practice:* An Introduction, Pearson India, 3rd Edition, 2018.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**9**
1.1	Introduction to Operations Management: Role of operations in an organisation,	2
1.2	historical evolution and perspectives, operations strategies and productivity in an organisation.	2
1.3	Facility Location and Layout: Factors influencing location planning, factor rating and center of gravity methods of location selection.	2
1.4	Types of facility layouts, comparison of layouts. Systematic Layout Planning (SLP), software packages for SLP.	3
	Module 2	**9**
2.1	Needs and use of forecasting methods	1
2.2	Causal and time series models, moving average method	2
2.3	Exponential smoothing methods. Trend, cycle, and seasonality components	2
2.4	Types of forecasting errors and analysis of forecast error	2
2.5	Comparison of forecasting methods based on errors	2
	Module 3	**9**
3.1	Objectives and Types of Inventories	1
3.2	EOQ and EBQ models for uniform and variable demand with and without shortages	3
3.3	Quantity discount models, safety stock	2
3.4	Selective Inventory Control: ABC Analysis, XYZ Analysis, VED Analysis	3
	Module 4	**9**
4.1	Aggregate Planning and the value of decision rules	1
4.2	Pure and Mixed strategies, Mathematical Models for Aggregate planning	3
4.3	Transportation Method	1
4.4	Master production schedule (MPS), Bill of Material (BOM), MRP and Implementation issues	2
4.5	MRP – II, Introduction to ERP	2
	Module 5	**9**
5.1	Job Shop Production planning, scheduling, shop loading, sequencing. Priority rules for dispatching jobs.	2
5.2	Job shop loading, sequencing. Priority rules for dispatching	3

	jobs.	
5.3	Business Process Re- engineering and Lean Manufacturing,	2
5.4	World-class manufacturing Concepts and Just-in-time systems.	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Demonstrate the concept of operations management.
2. List the strategies to improve productivity in an organization
3. Determine the location of the facility.

Course Outcome 2 (CO2):

1. Demonstrate the need and uses of demand forecasting.
2. Compute demand forecast.
3. Comparison of forecasting based on errors.

Course Outcome 3 (CO3):

1. Illustrate the concept of Inventory models
2. Derive an expression for EOQ
3. Comparison of selective inventory control techniques

Course Outcome 4 (CO4):

1. Compare aggregate planning strategies.
2. Compute APP using mathematical models.
3. List out the implementation issues of MRP.

Course Outcome 5 (CO5)

1. Illustrate the concept of production scheduling.
2. Find production schedule using various techniques.
3. Detail the concept of Lean Manufacturing.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SIXTH SEMESTER B TECH DEGREE EXAMINATION, MAY 2027

Course Code: **B24MEM63**

Course Name: **INTRODUCTION TO OPERATIONS MANAGEMENT**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Elaborate the system concept of production?

2 Identify the critical factors influencing the facility location.

3 Detail about the qualitative methods of forecasting.

4 What is forecasting accuracy?

5 Identify the different types of inventory cost.

6 What are the different types of replenishment systems in inventory control?

7 Differentiate between level production strategy and chase demand strategy.

8 Identify the basic inputs for MRP.

9 Explain the concept of the single machine scheduling problem.

10 Detail about lean manufacturing.

PART B

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

Module 1

11 a. What activities are involved in the operations function? How do operations interact with other functional areas? (7 marks)

b. The data regarding five existing facilities which are to be served by a single new facility is given in the table.

Existing facility (i)	1	2	3	4	5
Coordinates	5,10	20,5	15,20	30,25	25,5
No. of loads/year	100	300	200	300	100

Find the optimal location for a new facility using gravity location concept? (7 marks)

OR

12 A company is attempting to determine the location for a new outlet mall. The region where the outlet mall will be constructed includes four towns, which together have a sizable population base. The grid map coordinates of the four towns and the population of each are as follows:

Town	Coordinates		Population
	X	Y	
A	1000	1250	7000
B	1500	2700	9000
C	2000	700	11500
D	32	25	4300

a. Determine the best location for the outlet mall using the centre-of-gravity method.
b. Plot four towns and the location of the new mall on a grid map. (14 marks)

Module 2

13 a. How does adjusted exponential smoothing differ from exponential smoothing? What determines the choice of the smoothing constant for trend in an adjusted exponential smoothing model? (7 marks)

b. The following table represents the sales data of milk (in litres) sold by a milk booth.

Month	1	2	3	4	5	6	7
Sales	90	106	92	114	108	98	115

Compute the forecast for the 8^{th} month using four month moving average method. (7 marks)

OR

14 a. Detail about the different types of forecasting errors. (5 marks)

b. Using the data provided below, find MAPE, MAD and Tracking Signal, also infer about the values of tracking signal? (9 marks)

Period	**Demand**	**Forecast**
1	120	109
2	114	118
3	130	132
4	124	110
5	97	110

Module 3

15 a. Illustrate about economic order quantity? Derive an expression for EOQ? (7 marks)

b. The annual demand of an item in a company is 50,000 units. The cost of placing an order is Rs.250. Each item costs Rs.10. Carrying costs are 10% per year per unit of average inventory. Determine

i) Economic order quantity
ii) Cycle time
iii) Total variable cost of managing inventory (7 marks)

OR

16 Explain the different methods of selective inventory control. (14 marks)

Module 4

17 Find the feasible solution for the transportation problem using Vogel's approximation method. The demand and supply at different origins are given in the table. (14 marks)

Origin	D1	D2	D3	Supply
O1	4	14	8	10
O2	6	6	2	16
O3	10	8	14	14
O4	2	12	4	28
Demand	14	18	36	

OR

18 a. Illustrate the help of a block diagram, the role of APP in the master production schedule. (7 marks)

b. Detail about the role ERP in production scheduling. (7 marks)

Module 5

19 Consider the single machine scheduling problem.

Job (j)	Processing Time (t_j) min					
	1	2	3	4	5	6
Machine 1	5	10	8	9	6	12
Machine 2	7	8	13	7	11	10

Using Johnson's algorithm, obtain optimal sequence which will minimize the make span time. (14 marks)

OR

20 Discuss in detail about Just in time production system and Business process reengineering? (14 marks)

MAR ATHANASIUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution
Kothamangalam, Kerala, India

B.TECH MECHANICAL ENGINEERING

SEMESTER 6

(HONOURS)

SYLLABUS

B24MEH61	ADVANCED THEORY OF MACHINES	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course is designed to provide a comprehensive understanding and analysis of complex motion and forces within machinery and then incorporating them for real world application. The course includes static force analysis, dynamic force analysis, friction, governors, brakes and dynamometers. The course introduces key techniques for design, development and innovation in engines and automobiles and in robotic systems.

Prerequisites

Theory of machines

Course Outcomes

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

CO1	Apply principles of statics to determine forces, equilibrium, and friction in planar mechanisms. (Cognitive Knowledge Level: Apply)
CO2	Apply dynamic force analysis methods to determine inertia forces, shaking forces, and moments in planar and spatial mechanisms. (Cognitive Knowledge Level: Apply)
CO3	Apply friction models to determine forces and performance in bearings and clutch systems. (Cognitive Knowledge Level: Apply)
CO4	Apply governing principles to determine speed control characteristics and performance parameters of governors. (Cognitive Knowledge Level: Apply)
CO5	Apply braking and power measurement principles to determine the performance of brakes and dynamometers. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	–	–	1	–	–	–	–	–	1
CO2	3	2	–	–	1	–	–	–	–	–	1
CO3	3	2	–	–	1	1	–	–	–	–	1
CO4	3	1	–	–	–	–	–	–	–	–	1
CO5	3	2	–	–	1	1	–	–	–	–	1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test1 (%Marks)	Test2 (%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 (2numbers) :25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer any one. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Static Force Analysis of Mechanisms (8 hours)

Static force analysis: Forces - Couples - Conditions of equilibrium - free body diagram - Analysis of 4-bar linkage - Analysis of slider crank mechanisms - Analysis of cams - Friction force models - Force analysis using Coulomb friction and pin joint friction.

MODULE 2: Dynamic Force Analysis of Mechanisms (12 hours)

Dynamic force analysis: Dynamic force analysis of planar mechanism - Mass moments and products of inertia - Inertia forces and D'alembert's principle - Principle of superposition - shaking force and moments

Dynamic force analysis of spatial mechanism - Measuring mass moment of inertia - Translation of axes - Rotation of axes - Euler's equation of motion.

MODULE 3: Friction and Friction Devices (8 hours)

Friction: Friction in turning pairs - Friction circle - Pivot and collar friction - Flat pivot - Conical pivot - Flat collar bearing - friction in clutches - Single plate clutch - Multi-plate clutch - Cone clutch - Centrifugal clutch - Rolling friction - Anti-friction bearings - Greasy friction - Greasy friction at a journal - Friction axis of a link.

MODULE 4: Governors and Speed Control Mechanisms (8 hours)

Governors: Introduction – Classification - Watt governor - Porter governor - Proell governor - Hartnell governor - Wilson-Hartnell governor - Spring controlled gravity governor - Characteristics of a governor - Effort of a governor - Power of a governor - Controlling force.

MODULE 5: Brakes and Dynamometers (9 hours)

Brakes and Dynamometers: Introduction - Block brakes - Band brakes - Band and Block brake - Internal expanding shoe brake - Effect of braking on vehicles.

Dynamometers: Absorption dynamometers - Rope brake dynamometer - Hydraulic dynamometer - Transmission dynamometers - Epicyclic dynamometer - Belt transmission dynamometers.

Text Books

1. John J. Uicker Jr., Gorden R. Pennock & Joseph E. Shigley, *Theory of Machines and Mechanisms*, Cambridge University Press.
2. Mahmoud A. Mostafa, *Mechanics of machinery,* CRC Press.
3. Thomas Bevan, *The Theory of Machines,* CBS Publications.
4. Charles E. Wilson & J. Peter Sadler, *Kinematics and Dynamics,* Pearson Edn Ltd.
5. S. S. Ratan, *Theory of Machines,* Mc Graw Hill Education

Reference Books

1. Arthur G. Erdman & George N Sandor, *Mechanism Design,* Pearson Education.
2. V. P. Singh, *Theory of Machines,* Dhanpat Rai & Co.
3. C.S. Sharma & Kamlesh Purohit, *Theory of Mechanisms and Machines,* PHI Learning

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module1	**8**
1.1	Static force analysis: Forces, Couples; Conditions of equilibrium; free body diagram	2
1.2	Analysis of 4-bar linkage; Analysis of slider crank mechanisms	2
1.3	Analysis of cams; Friction force models	2
1.4	Force analysis using Coulomb friction and pin joint friction	2
	Module2	**12**
2.1	Dynamic force analysis: Dynamic force analysis of planar mechanism; Mass moments and products of inertia; Inertia forces and D'alembert's principle; Principle of superposition; shaking force and moments	2
2.2	Dynamic force analysis of slider crank mechanism	2
2.3	Dynamic force analysis of four bar mechanism	2
2.4	Dynamic force analysis of spatial mechanism; Measuring mass moment of inertia; Translation of axes, Rotation of axes; Euler's equation of motion.	6
	Module3	**8**
3.1	Friction: Friction in turning pairs; Friction circle; Pivot and collar friction; Flat pivot	1
3.2	Conical pivot; Flat collar bearing	1
3.3	Friction in clutches; Single plate clutch; Multi-plate clutch	2
3.4	Cone clutch; Centrifugal clutch	2
3.5	Rolling friction; Anti-friction bearings; Greasy friction; Greasy friction at a journal	1
3.6	Friction axis of a link.	1
	Module 4	**8**
4.1	Governors: Introduction; Classification; Watt governor	1
4.2	Porter governor; Proell governor	3
4.3	Hartnell governor	1
4.4	Wilson-Hartnell governor	1
4.5	Spring controlled gravity governor	1
4.6	Characteristics of a governor; Effort of a governor; Power of a governor; Controlling force.	1
	Module 5	**9**
5.1	Brakes and Dynamometers: Introduction; Block brakes	1
5.2	Band brakes; Band and Block brake	2
5.3	Internal expanding shoe brake Effect of braking on vehicles	2
5.4	Dynamometers: Absorption dynamometers; Rope brake dynamometer	1
5.5	Hydraulic dynamometer; Transmission dynamometers	2
5.6	Epicyclic dynamometer; Belt transmission dynamometers	1
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. What do you mean by applied constraint forces? Explain.
2. Define principle of superposition.
3. Explain the principle of virtual work with illustration.
4. Illustrate with neat sketch the static force analysis of a Whitworth quick return mechanism.

Course Outcome 2 (CO2):

1. State and explain D'Alembert's principle.
2. Differentiate between inertia force and inertia torque.
3. Illustrate with neat sketch the dynamic force analysis of a four bar mechanism.

Course Outcome 3 (CO3):

1. Explain the terms friction circle, friction couple and friction axis.
2. What do you mean by film friction? State its laws.
3. If the capacity of a single plate clutch decreases by 13 % during the initial wear period, determine the minimum value of the ratio of internal diameter to external diameter for the same axial load. Consider both the sides of the clutch plate to be effective.

Course Outcome 4 (CO4):

1. Describe the function of s Proell governor and establish a relation among various forces acting on the bent link.
2. Describe the function of s Porter governor and establish a relation among various forces acting on the governor.
3. Discuss the effect of friction on the functioning of a Porter governor. Deduce its governing equation taking into account the friction at the sleeve.

Course Outcome 5 (CO5)

1. Differentiate between self-locking and self-energised brake.
2. Differentiate between a brake and a clutch.
3. In a belt transmission dynamometer, the driving pulley rotates at 300 rpm. The distance between the centre of the driving pulley and dead mass is 800 mm. The diameter of each of the driving as well as the intermediate pulleys is equal to 360 mm. Find the value of the dead mass required to maintain the lever in ahorizontal position when the power transmitted is 3 kW. Also, find its value when the belt just begins to slip on the driving pulley, μ being 0.25 and the maximum tension in the belt 1200 N.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.:.....

Name:.....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SIXTH SEMESTER BTECH DEGREE EXAMINATION, MAY 2027

Course Code: **B24MEH61**

Course Name: **ADVANCED THEORY OF MACHINES**

Max.Marks:100 Duration:3 hours

PARTA

Answer all questions. Each question carries 3 marks.

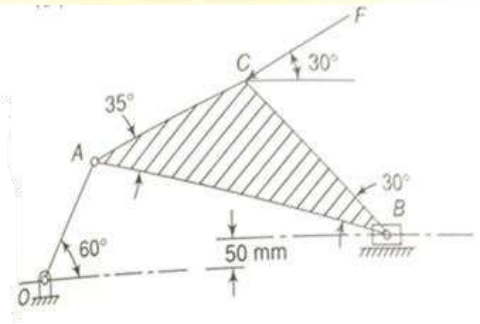
1 What do you mean by applied constraint forces? Explain.
2 Define and explain the super position theorem as applicable to a system of forces acting on a mechanism.
3 State and explain D'Alembert's principle.
4 Differentiate between inertia force and inertia torque.
5 Explain the terms friction circle, friction couple and friction axis.
6 What do you mean by film friction? State its laws.
7 Describe the function of s Proell governor and establish a relation among various forces acting on the bent link.
8 What are centrifugal governors? How do they differ from inertia governors?
9 Differentiate between self-locking and self-energised brake.
10 Differentiate between absorption dynamometers and transmission dynamometers.

PARTB

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

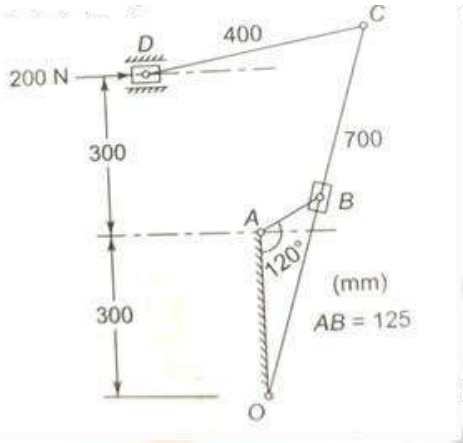
Module 1

11 For the mechanism shown in figure find the required input torque for the static equilibrium. The lengths OA and AB are 250 mm and 650 mm respectively. F = 500 N. (14 marks)



OR

12 Determine the torque required to be applied to the link OA for the static equilibrium of the mechanism shown in figure. (14 marks)



Module 2

13 The dimensions of a four link mechanism are AB = 500 mm, BC = 660 mm, CD = 560 mm and AD = 1000 mm. The link AB has an angular velocity of 10.5 rad/sec counter clockwise and an angular retardation of 26 rad/sec^2 at that instant when it makes an angle of 60 degree with AD, the fixed link. The mass of the links BC and CD is 4.2 kg/m length. The link AB has a mass of 3.54 kg, the centre of which lies 200 mm from A and a moment of inertia of 88500 kg.mm^2. Neglecting gravity and friction effects, determine the instantaneous value of the drive torque required to be applied on AB to overcome inertia forces. (14 marks)

OR

14 The dimensions of a four link mechanism are, AB = 550 mm, BC = 726 mm, CD = 616 mm and AD = 1100 mm. The link AB has an angular velocity of 11 rad/sec counter clockwise and an angular retardation of 28 rad/sec^2 at that instant when it makes an angle of 60 degree with AD, the fixed link. The mass of the links BC and CD is 3.5 kg/m length. The link AB has a mass of 3.26 kg, the centre of which lies 220 mm from A and a moment of inertia of 101223 kg.mm^2. Neglecting gravity and friction effects, determine the instantaneous value of the drive torque required to be applied on AB to overcome inertia forces. (14 marks)

Module 3

15 A multiple plate clutch of alternate bronze and steel plates having effective diameters of 175 mm and 72.5 mm has to transmit 22 kW at 2000 rpm. The end thrust is 1700 N and coefficient of friction is 0.1. Calculate the number of plates necessary, assuming uniform pressure distribution on the plates. (14 marks)

OR

16 Determine the axial force required to engage a cone clutch transmitting 25 kW of power at 750 rpm. Average friction diameter of the cone is 400 mm, semicone angle 10 degree and coefficient of friction 0.25. Also find the width of the friction cone. (14 marks)

Module 4

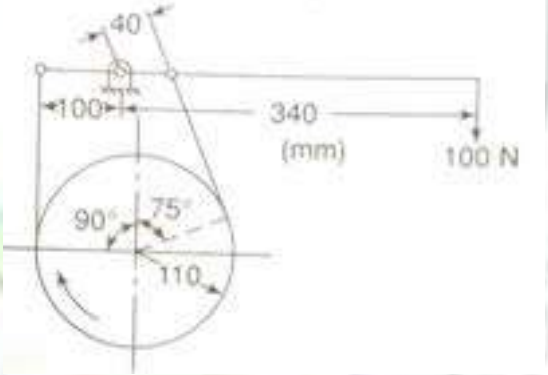
17 A Porter governor has each of its arms of 175 mm length pivoted on the axis of the governor. The radii of rotation of the balls at the minimum and the maximum speeds are 105 mm and 140 mm respectively. The mass of the sleeve is 20 kg and of each ball is 5 kg. Determine the range of speed when the friction at the sleeve is 15 N. (14 marks)

OR

18 The mass of each ball of a Proell governor is 3 kg and the weight on the sleeve is 20 kg. Each arm is 220 mm long and the pivots of the upper and the lower arms are 20 mm from the axis. For the mid position of the sleeve the extension links of the lower arms are vertical, the height of the governor is 180 mm and the speed is 150 rpm. Determine the lengths of the extension links and the tension in the upper arms. (14 marks)

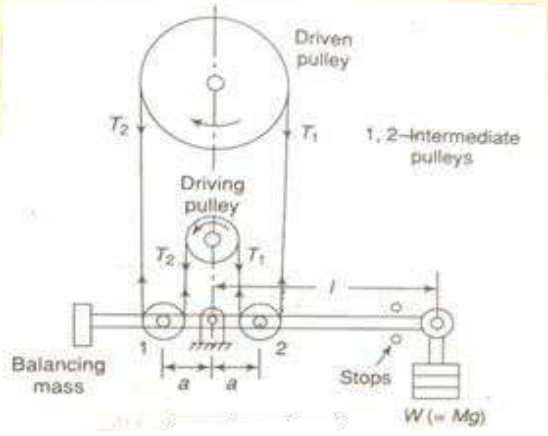
Module 5

19 The band brake shown in figure is applied to a shaft carrying a flywheel of 300 kg mass with a radius of gyration of 400 mm and running at 340 rpm. Find the torque applied due to a pull of 100 N if μ = 0.25. Also find the number of revolutions of the flywheel before it comes to rest. (14 marks)



OR

20 In a belt transmission dynamometer, the diameters of the driving and driven pulleys are 0.36 m and 0.8 m respectively. The power transmitted from the driving to the driven shaft is 20 kW. The speed of the driving shaft is 500 rpm. If l = 1.2 m and a = 400 mm, determine the weight on the lever shown in figure. (14 marks)



B24MEH62	SOLAR THERMAL ENGINEERING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course provides a comprehensive introduction to the principles, technologies, applications and advancements in solar thermal energy. Combining theoretical concepts with practical insights and case studies, it enables participants to gain holistic understanding of solar thermal energy systems and their wide range of applications across various sectors.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain solar radiation principles and measurement techniques required for assessing the performance of solar energy systems. (Cognitive Knowledge Level: Understand)
CO 2	Explain and apply the principles of solar energy collection using flat plate and concentrating collectors, with emphasis on construction and efficiency. (Cognitive Knowledge Level: Apply)
CO 3	Apply fundamental principles to determine the performance and basic economic aspects of solar air and water heating systems. (Cognitive Knowledge Level: Apply)
CO 4	Explain and apply solar energy storage methods by considering storage quality, capacity and duration. (Cognitive Knowledge Level: Apply)
CO 5	Explain the working principles and applications of solar thermal systems and photovoltaic devices with reference to power output and conversion efficiency. (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	1	–	–	–	–	1
CO 2	3	2	1	–	2	1	–	–	–	–	1
CO 3	3	2	1	–	2	2	–	–	–	–	1
CO 4	3	2	–	–	1	3	–	–	–	–	1
CO 5	3	1	–	–	1	2	–	–	–	–	2

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	20	10	10
Understand	40	30	30
Apply	40	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Solar Radiation Fundamentals and Measurement (8 hours)

Structure of the sun, Solar constant, Terrestrial radiation, Spectral distribution of extra-terrestrial radiation, Revolution of earth, Seasons, Basic earth sun angles, Diffuse and direct radiation, Solar radiation under actual conditions, Air mass, Solar radiation on horizontal and inclined surfaces, Shading, Sun path diagram, Greenwich civil time, Local civil time, Solar time, Day length, Hourly, daily and monthly average solar radiation.

Measurement of solar radiation, Pyrheliometers, Pyranometers, Sunshine recorder.

MODULE 2: Solar Energy Collection Systems (9 hours)

Greenhouse effect, Flat plate collectors, Classification and construction, Thermal losses and collector efficiency, Thermal analysis of flat plate collectors, Collector performance, Heat removal factor, Concentrating collectors, Classification of concentrators, Orientation and sun tracking systems, Cylindrical parabolic collector, Optical losses, Thermal analysis, Compound parabolic collector, Paraboloid dish collector, Central receiver collector, Thermal and radiative properties of collector cover materials.

MODULE 3: Solar Air and Water Heating Systems (9 hours)

Solar air heaters, Description and classification, Non-porous absorber plate type air heaters, Air heaters with porous absorbers, Thermal analysis,Two pass solar air heaters, Air heaters with finned absorbers, Non-porous absorber plate type collectors, Thermal analysis, Solar water heaters, Natural circulation and forced circulation water heaters, Integral collector storage systems, Testing and rating of solar water heaters, Economics of solar water heating**.**

MODULE 4: Solar Energy Storage Technologies (9 hours)

Thermal, electrical and chemical methods of storage, Quality, capacity and duration of storage, Sensible heat storage, Properties of sensible heat storage materials, Liquid storage, Size and configuration, Packed bed exchanger storage, Latent heat storage, Phase change materials for storage, Properties of phase change materials, Thermochemical storage, Electrical storage, Chemical storage, Energy storage in building materials, Solar ponds, Convecting solar ponds, Non convecting solar ponds, Salt gradient solar ponds.

MODULE 5: Solar Thermal and Photovoltaic Systems (10 hours)

Solar heating systems, Passive and active systems, Solar house, Solar cooling systems, Solar drying, Solar distillation, Solar cooking, Solar thermal power plant, Low temperature, medium temperature and high temperature thermal power systems, Solar thermal energy for process heating, Solar photovoltaic cells, Photovoltaic principles, Power output and conversion efficiency, Solar furnaces, Solar pumps.

Text Books

1. John A. Duffie, William A. Beeckman, Solar Engineering of Thermal Processes, John Wiley & Sons, Inc.
2. Ibrahim Dincer, Marc A. Rosen, Thermal Energy Storage Systems and Applicaions, John Wiley & Sons, Inc.

3. G.N. Tiwari, Solar Energy - Fundamentals, Design, Modelling and Applications, Narosa Publishing House.
4. D.Y. Goswami, F Kreith and J.F. Krieder, Principles of Solar Engineering, Taylor and Francis, Philadelphia.
5. J. Twidell and T. Weir, Renewable Energy Resources, E & F.N. Spon Ltd, London.
6. Solar energy and non - conventional energy sources, Dhanpat Rai & Co. (P) Ltd.

Reference Books

1. G.D. Rai, Solar Energy Utilisation, Khanna Publishers.
2. S.P.Sukhatme, Solar Energy - Principles of Thermal Collection and Storage, Tata Mc-Graw Hill Publishing Company Limited.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**8**
1.1	Structure of the sun, Solar constant, Terrestrial radiation, Spectral distribution of extra-terrestrial radiation, Revolution of earth.	2
1.2	Seasons, Basic earth sun angles, Diffuse and direct radiation, Solar radiation under actual conditions, Air mass, Solar radiation on horizontal and inclined surfaces.	2
1.3	Shading, Sun path diagram, Greenwich civil time, Local civil time, Solar time, Day length, Hourly, daily and monthly average solar radiation.	2
1.4	Measurement of solar radiation, Pyrheliometers, Pyranometers, Sunshine recorder.	2
	Module 2	**9**
2.1	Greenhouse effect, Flat plate collectors, Classification and construction.	2
2.2	Thermal losses and collector efficiency, Thermal analysis of flat plate collectors, Collector performance, Heat removal factor.	2
2.3	Concentrating collectors, Classification of concentrators, Orientation and sun tracking systems, Cylindrical parabolic collector.	2
2.4	Optical losses, Thermal analysis, Compound parabolic collector, Paraboloid dish collector, Central receiver collector.	2
2.5	Thermal and radiative properties of collector cover materials.	1
	Module 3	**9**
3.1	Solar air heaters, Description and classification, Non-porous absorber plate type air heaters, Air heaters with porous absorbers.	2

3.2	Thermal analysis, Two pass solar air heaters. Air heaters with finned absorbers.	2
3.3	Non-porous absorber plate type collectors, Thermal analysis.	2
3.4	Solar water heaters, Natural circulation and forced circulation water heaters, Integral collector storage systems.	1
3.5	Testing and rating of solar water heaters, Economics of solar water heating.	2
	Module 4	**9**
4.1	Thermal, electrical and chemical methods of storage, Quality, capacity and duration of storage.	2
4.2	Sensible heat storage, Properties of sensible heat storage materials, Liquid storage, Size and configuration.	2
4.3	Packed bed exchanger storage, Latent heat storage, Phase change materials for storage, Properties of phase change materials, Thermochemical storage.	2
4.4	Electrical storage, Chemical storage, Energy storage in building materials.	1
4.5	Solar ponds, Convecting solar ponds, Non convecting solar ponds, Salt gradient solar ponds.	2
	Module 5	**10**
5.1	Solar heating systems, Passive and active systems, Solar house.	2
5.2	Solar cooling systems, Solar drying, Solar distillation, Solar cooking.	2
5.3	Solar thermal power plant, Low temperature, medium temperature and high temperature thermal power systems.	2
5.4	Solar thermal energy for process heating, Solar photovoltaic cells.	2
5.5	Photovoltaic principles, Power output and conversion efficiency, Solar furnaces, Solar pumps.	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the principal characteristics of sun and earth.
2. Determine the average value of total radiation on a horizontal surface at lattitude22^{O}3'N and longitude73^{O}13'E during the month of March. The constants a and b are equal to 0.28 and0.48 respectively and average sunshine hours per day is 10.15.
3. Explain a sunshine recorder with figure.

Course Outcome 2 (CO2):

1. Explain any two evacuated collectors with figures**.**
2. Explain the different selective absorber coatings used in flat plate collectors.
3. Determine the top loss coefficient for a single glass cover with the following specifications: Plate emittance = 0.94, Plate to cover spacing = 2.54 cm, Ambient temperature =25^{O}C, Wind speed = 10 m/s, Mean plate temperature = 70^{O}C, Back insulation thickness = 5 cm, Insulation conductivity = 0.045 W/m-K. The collector tilt = 30^{O}.

Course Outcome 3 (CO3):

1. Explain an air heating solar collector with figure.
2. Analyse the thermal losses in an air heating flat plate collector.
3. Explain a closed loop configuration solar water heating system.

Course Outcome 4 (CO4):

1. Explain the different phase change materials and analyse their properties.
2. Explain the different classifications of solar energy storage systems.
3. Explain the extraction of thermal energy stored in a solar pond.

Course Outcome 5 (CO5)

1. Explain a basin type solar still with a schematic diagram.
2. Explain a photovoltaic system for power generation.
3. Explain the working of a solar operated absorption air conditioner

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: **B24MEH62**

Course Name: **SOLAR THERMAL ENGINEERING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Differentiate direct and diffused radiations.

2 Analyse spectral distribution of extra-terrestrial radiation.

3 Analyse the losses occurring in a focusing collector.

4 Differentiate line focusing and point focusing collectors.

5 Explain the concept of thermosiphon in solar water heater.

6 Explain the role of insulation and glazing in solar air heaters.

7 Differentiate sensible heat storage and latent heat storage.

8 Analyse the thermochemical storage of solar energy.

9 Differentiate passive and active systems.

10 Analyse the effect of temperature on the performance of photovoltaic cells.

PART B

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

Module 1

11 a. Explain the principal characteristics of sun and earth. (7 marks)

b. Explain a pyrheliometer with figure. (7 marks)

OR

12 Determine the average value of total radiation on a horizontal surface at lattitude$22^{O}3$'N and longitude$73^{O}13$'E during the month of March. The constants a and b are equal to 0.28 and0.48 respectively and average sunshine hours per day is 10.15. (14 marks)

Module 2

13		Determine the top loss coefficient for a single glass cover with the following specifications: Plate emittance = 0.94, Plate to cover spacing = 2.54 cm, Ambient temperature =25^{O}C, Wind speed = 10 m/s, Mean plate temperature = 70^{O}C, Back insulation thickness = 5 cm, Insulation conductivity = 0.045 W/m-K. The collector tilt = 30^{O}.	(14marks)

OR

14	a.	Explain the effect of fluid inlet temperature, mass flow rate and concentration ratio on the performance of focusing collectors.	(7 marks)
	b	Explain the selective absorber coatings used in flat plate collectors.	(7 marks)

Module 3

15	a.	Analyze the thermal losses in a flat plate collector.	(7 marks)
	b.	Explain the different types of non-porous absorber plate type collectors.	(7 marks)

OR

16	a.	Explain a space heating system using solar heaters with a block diagram.	(7 marks)
	b.	Explain an integral collector storage system with figure.	(7 marks)

Module 4

17	a.	Explain the major classifications of solar energy storage systems.	(7 marks)
	b.	Explain the different phase change materials and analyse their properties.	(7 marks)

OR

18		Explain the principle of operation of salt gradient solar pond.	(14 marks)

Module 5

19		Explain the different types of solar furnaces with figures.	(14 marks)

OR

20		Explain the working of a solar pump with a schematic diagram.	(14 marks)

B24MEH63	ADVANCED CHARACTERISATION TECHNIQUES	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course provides an overview of modern materials characterisation techniques used to study the structure, composition, and properties of engineering materials across different length scales. It introduces microstructural analysis and advanced imaging, diffraction, spectroscopy, thermal, mechanical, and electrical methods, with emphasis on structure–property relationships. The course equips students with the knowledge to select suitable characterisation techniques, prepare samples, and interpret data for evaluating the behaviour of advanced and functional materials.

Prerequisites

Nil

Course Outcomes

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

CO 1	Apply principles of materials characterisation and optical microscopy to examine and interpret material microstructures. (Cognitive Knowledge Level: Apply)
CO 2	Apply electron microscopy and X-ray techniques (SEM, TEM, XRD) to determine material structure, composition, and crystallography. (Cognitive Knowledge Level: Apply)
CO 3	Apply surface analysis and spectroscopic techniques (AFM/STM, XPS, UV-Vis, IR, Raman, FTIR) to determine bonding, chemistry, and surface behaviour of materials. (Cognitive Knowledge Level: Apply)
CO 4	Apply thermal, electrical, and electrochemical characterisation methods to determine material stability and functional behaviour. (Cognitive Knowledge Level: Apply)
CO 5	Apply standard mechanical testing methods to determine material properties and relate them to material performance. (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
CO 2	3	2	1	–	3	–	–	–	–	–	1
CO 3	3	2	–	–	3	–	–	–	–	–	1
CO 4	3	2	–	–	2	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	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which students should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Optical Microscopy and Characterisation Basics (9 hours)

Introduction to Materials Characterisation; Need for characterisation: structure–property correlations; Classification of techniques – Destructive & non-destructive, Microstructural, compositional, mechanical; Sampling and specimen preparation fundamentals.

Optical Microscopy: Fundamentals of optics; Construction and components of an optical microscope; Principles of light microscopy; Image formation: magnification, numerical aperture, resolution limits; Metallographic sample preparation steps; Imaging modes and variants: Bright-field microscopy, Dark-field microscopy, Polarised light microscopy, Phase contrast microscopy, Differential Interference Contrast (DIC), Fluorescence microscopy.

MODULE 2: Electron Microscopy and X-ray Techniques (10 hours)

Scanning Electron Microscopy (SEM): Introduction to SEM; Instrumental details and image formation of SEM; Various imaging techniques and spectroscopy; Sample preparation and applications of SEM; Chemical Analysis in SEM, Energy Dispersive X-ray Spectroscopy (EDS), Wavelength Dispersive Spectroscopy (WDS), Conductive and non-conductive sample preparation.

Transmission Electron Microscopy (TEM): Introduction to transmission electron microscopy (TEM); Foil preparation: mechanical thinning, ion milling, FIB, ultramicrotomy; Image Formation & Diffraction; Advanced TEM Techniques: High Resolution TEM (HRTEM), STEM (Scanning TEM).

X-ray Based Techniques: X-ray generation: sealed tubes, rotating anode sources; fundamentals of X-ray scattering; Bragg's law derivation and the factors affecting the intensity; Crystallite size, effect of strain on the intensity; Profile fit, indexing, peak broadening; Quantitative analysis, residual stress analysis.

MODULE 3: Surface Analysis and Spectroscopy (8 hours)

Surface Analysis: Atomic force microscopy, scanning tunneling microscopy, X-ray photoelectron spectroscopy.

Spectroscopy: Introduction, Ultraviolet-visible light (UV-vis) Spectroscopy, Principle, sample preparation, basic instrumentation, applications; Infrared Spectroscopy (IR), Basic theory, sample preparation, instrumentation, applications; Fourier Transform Spectrometry, Principle, applications; Raman Spectroscopy, Principle, instrumentation, applications; Anger Electron Spetcroscopy, Principle, instrumentation, applications.

MODULE 4: Thermal, Electrical, and Electrochemical Characterisation (8 hours)

Thermal Analysis: Differential Scanning Calorimetry (DSC); Thermogravimetric Analysis (TGA); Differential Thermal Analysis (DTA); Thermal conductivity & diffusivity measurements.

Electrical Characterisation: Electrical resistivity measurements; Thin films vs bulk sample; Hall effect measurements; Magnetoresistance.

Materials characterization by electrochemical methods: Cyclic voltammetry, Electrochemical Impedance spectroscopy: experiment and its applications.

MODULE 5: Mechanical Testing of Materials (10 hours)

Mechanical testing: Introduction; The Need for Testing; Material Property tests.

Hardness test: Property of Hardness; Mohs' Scale of Hardness; Static Indentation Tests; Brinell Hardness Test; Vickers Diamond Hardness Test; Rockwell Hardness Test; Microhardness Testing; Knoop Diamond Microhardness Test; Shore Scleroscope Test; Relationships between Hardness and Other Properties.

Tensile, Compressive and Shear Tests: Stress and Strain; Testing Machines; Measurement of Strain; Tensile Testing of Metals; Determining the Tensile Strength of Brittle Materials; Compression Testing; Testing in Shear.

Notch Impact and Fracture Toughness Testing: Fracture; Temperature Effects and Ductile-brittle transition; Notch Impact Tests; Izod Notch Impact Test; Charpy Notch Impact Test; Notch Impact Values; Fracture Toughness Determination.

Fatigue and Fatigue Testing: Fatigue; Factors Affecting Fatigue; Fatigue Testing; Significance of Test Results.

Creep and Creep Testing: Creep; Creep Testing; Stress-rupture Testing; Relaxation Testing; Significance of Creep Test Results.

Text Books

1. William D. Callister and David G. Rethwisch, *Materials Science and Engineering: An Introduction*, Wiley.
2. Sam Zhang, Lin Li and Ashok Kumar, *Materials Characterization Techniques*; CRC Press.
3. Cullity, B.D., and Stock, R.S., *Elements of X-Ray Diffraction*, Prentice-Hall.
4. Wendlandt, W.W., *Thermal Analysis*, John Wiley & Sons.
5. Wachtman, J.B., Kalman, Z.H., *Characterization of Materials*, Butterworth Heinemann.

Reference Books

1. Materials characterisation, Vol. 10, ASM hand book, 1997.
2. G. Dieter, *Mechanical Metallurgy*, Mc-Graw Hill, 1996.
3. Vernon John, *Testing Of Materials*, Macmillan Education ltd , 1992.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**9**
1.1	Introduction to Materials Characterisation; Need for characterisation: structure–property correlations; Classification of techniques – Destructive & non-destructive, Microstructural, compositional, mechanical; Sampling and specimen preparation fundamentals.	2
1.2	Optical Microscopy: Fundamentals of optics; Construction and components of an optical microscope; Principles of light microscopy; Image formation: magnification, numerical aperture, resolution limits.	4
1.3	Metallographic sample preparation steps; Imaging modes and variants: Bright-field microscopy, Dark-field microscopy, Polarised light microscopy, Phase contrast microscopy, Differential Interference Contrast (DIC), Fluorescence microscopy.	3
	Module 2	**10**
2.1	Scanning Electron Microscopy (SEM): Introduction to SEM; Instrumental details and image formation of SEM; Various imaging techniques and spectroscopy; Sample preparation and applications of SEM; Chemical Analysis in SEM, Energy Dispersive X-ray Spectroscopy (EDS), Wavelength Dispersive Spectroscopy (WDS), Conductive and non-conductive sample preparation.	4
2.2	Transmission Electron Microscopy (TEM): Introduction to transmission electron microscopy (TEM); Foil preparation: mechanical thinning, ion milling, FIB, ultramicrotomy; Image Formation & Diffraction; Advanced TEM Techniques: High Resolution TEM (HRTEM), STEM (Scanning TEM).	3
2.3	X-ray Based Techniques: X-ray generation: sealed tubes, rotating anode sources; fundamentals of X-ray scattering; Bragg's law derivation and the factors affecting the intensity; Crystallite size, effect of strain on the intensity; Profile fit, indexing, peak broadening; Quantitative analysis, residual stress analysis.	3
	Module 3	**8**
3.1	Surface Analysis: Atomic force microscopy, scanning tunneling microscopy, X-ray photoelectron spectroscopy.	2
3.2	Spectroscopy: Introduction, Ultraviolet-visible light (UV-vis) Spectroscopy, Principle, sample preparation, basic instrumentation, applications; Infrared Spectroscopy (IR), Basic theory, sample preparation, instrumentation, applications;	3
3.3	Fourier Transform Spectrometry, Principle, applications; Raman Spectroscopy, Principle, instrumentation, applications; Anger Electron Spetcroscopy, Principle, instrumentation, applications.	3
	Module 4	**8**
4.1	Thermal Analysis: Differential Scanning Calorimetry (DSC); Thermogravimetric Analysis (TGA); Differential Thermal	3

	Analysis (DTA); Thermal conductivity & diffusivity measurements.	
4.2	Electrical Characterisation: Electrical resistivity measurements; Thin films vs bulk sample; Hall effect measurements; Magnetoresistance.	2
4.3	Materials characterization by electrochemical methods: Cyclic voltammetry, Electrochemical Impedance spectroscopy: experiment and its applications.	3
	Module 5	**10**
5.1	Mechanical testing: Introduction; The Need for Testing; Material Property tests.	1
5.2	Hardness test: Property of Hardness; Mohs' Scale of Hardness; Static Indentation Tests; Brinell Hardness Test; Vickers Diamond Hardness Test; Rockwell Hardness Test; Microhardness Testing; Knoop Diamond Microhardness Test; Shore Scleroscope Test; Relationships between Hardness and Other Properties.	2
5.3	Tensile, Compressive and Shear Tests: Stress and Strain; Testing Machines; Measurement of Strain; Tensile Testing of Metals; Determining the Tensile Strength of Brittle Materials; Compression Testing; Testing in Shear.	3
5.4	Notch Impact and Fracture Toughness Testing: Fracture; Temperature Effects and Ductile-brittle transition; Notch Impact Tests; Izod Notch Impact Test; Charpy Notch Impact Test; Notch Impact Values; Fracture Toughness Determination.	2
5.5	Fatigue and Fatigue Testing: Fatigue; Factors Affecting Fatigue; Fatigue Testing; Significance of Test Results. Creep and Creep Testing: Creep; Creep Testing; Stress-rupture Testing; Relaxation Testing; Significance of Creep Test Results.	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the need for materials characterisation and its role in structure–property correlations.
2. Classify characterisation techniques into destructive, non-destructive, microstructural, compositional, and mechanical methods.
3. Understand the principles of optical microscopy, including image formation, magnification, numerical aperture, and resolution limits.
4. Analyze different optical imaging modes: bright-field, dark-field, polarised light, phase contrast, DIC, and fluorescence microscopy.
5. Appreciate the importance of careful sample preparation and accurate microscopy in material evaluation.

Course Outcome 2 (CO2):

1. Describe the working principles and instrumental components of SEM and TEM.
2. Compare various imaging and spectroscopic techniques (EDS, WDS, HRTEM, STEM) and their applications.
3. Explain X-ray generation, Bragg's law, diffraction, crystallite size determination, strain effects, and residual stress analysis.
4. Recognize the role of advanced microscopy and X-ray techniques in materials research and quality control.

Course Outcome 3 (CO3):

1. Explain the principles of surface characterisation techniques: AFM, STM, and XPS.
2. Describe the working, instrumentation, and applications of UV-Vis, IR, FTIR, Raman, and Auger Electron Spectroscopy.
3. Develop a scientific approach towards selecting suitable surface analysis and spectroscopic techniques for specific material studies.

Course Outcome 4 (CO4):

1. Explain principles, instrumentation, and applications of thermal analysis: DSC, TGA, DTA, and thermal conductivity/diffusivity measurements.
2. Describe electrical characterisation methods including resistivity, Hall effect, and magnetoresistance measurements.
3. Understand electrochemical methods such as cyclic voltammetry and electrochemical impedance spectroscopy.
4. Appreciate the importance of thermal and electrical characterisation in material selection and design.

Course Outcome 5 (CO5)

1. Explain the significance of mechanical testing and various material property tests.
2. Describe hardness testing methods (Brinell, Rockwell, Vickers, Knoop, Shore), tensile, compressive, shear, impact, fracture toughness, fatigue, and creep testing principles.
3. Interpret relationships between hardness, strength, toughness, and other mechanical properties.
4. Analyse stress-strain data and evaluate material performance under different loading conditions.
5. Recognise the ethical and practical importance of accurate mechanical testing in engineering design and safety.

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: **B24MEH63**

Course Name: **ADVANCED CHARACTERISATION TECHNIQUES**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define numerical aperture and explain its significance in optical microscopy.
2. Differentiate between bright-field and dark-field microscopy.
3. List any three differences between SEM and TEM.
4. State Bragg's law and mention any two factors affecting XRD peak intensity
5. What is the principle of Raman spectroscopy?
6. Distinguish between AFM and STM.
7. Write any three differences between DSC and DTA.
8. What is the Hall effect? Mention its significance.
9. Define fatigue and mention two factors affecting fatigue life.
10. State the difference between Charpy and Izod impact tests

PART B

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

Module 1

11. Discuss the steps involved in metallographic specimen preparation. (14 Marks)

OR

12. Explain image formation in optical microscopy with reference to magnification, resolution, and numerical aperture. ` (14 Marks)

Module 2

13. Explain the working principle and instrumentation of SEM**.** (14 Marks)

OR

14. Describe foil preparation techniques for TEM, including mechanical thinning, ion milling, and FIB. (14 Marks)

Module 3

15. Describe the working and applications of AFM. (14 Marks)

OR

16. Discuss the principle and applications of Raman spectroscopy. (14 Marks)

Module 4

17. Explain DSC and TGA techniques with suitable diagrams and applications. (14 Marks)

OR

18. Discuss cyclic voltammetry and electrochemical impedance spectroscopy. (14 Marks)

Module 5

19. Explain the procedure for conducting a tensile test and interpreting stress–strain curves. (14 Marks)

OR

20. Discuss fatigue failure and S–N curve generation through fatigue testing. (14 Marks)

MAR ATHANASIUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution
Kothamangalam, Kerala, India

B.TECH MECHANICAL ENGINEERING

SEMESTER 7

SYLLABUS

SEMESTER 7

SLOT	COURSE NO.	COURSES	L-T-P-S	HOURS	CREDIT
A	B24ME4T01	PROJECT MANAGEMENT	2-1-0-4	3	3
B	B24ME4P3x	PROGRAMME ELECTIVE III	2-1-0-4	3	3
C	B24ME4P4x	PROGRAMME ELECTIVE IV	2-1-0-4	3	3
D	B24ME4G2x	OPEN ELECTIVE II	2-1-0-4	3	3
E	B24HU4T04	DISASTER MANAGEMENT AND INDUSTRIAL SAFETY	2-1-0-4	3	3
G	B24ME4L10	ADVANCED MECHANICAL ENGINEERING LAB	0-0-3-2	3	2
H	B24ME4L11	PROJECT PHASE 1	0-0-6-2	6	3
J	B24ME4L12	SEMINAR	0-0-4-1	4	2
K	B24ME4T02	VIVA VOCE	0-0-0-0	-	1
M	B24MEM7x	MINOR	3-1-0-5	4	4
N	B24MEH7x	HONOURS	3-1-0-5	4	4
			TOTAL*	**36**	**23**

PROGRAMME ELECTIVE III

B24ME4P31	PRODUCT DESIGN AND DEVELOPMENT
B24ME4P32	ADVANCED DESIGN SYNTHESIS
B24ME4P33	INDUSTRIAL TRIBOLOGY
B24ME4P34	RENEWABLE ENERGY
B24ME4P35	COMPUTATIONAL FLUID DYNAMICS
B24ME4P36	INDUSTRIAL HYDRAULICS
B24ME4P37	ADVANCED METAL JOINING TECHNIQUES
B24ME4P38	ADVANCED MANUFACTURING TECHNIQUES
B24ME4P39	SURFACE ENGINEERING AND COATING TECHNOLOGY

PROGRAMME ELECTIVE IV

B24ME4P41	OPTIMIZATION TECHNIQUES AND APPLICATIONS
B24ME4P42	FRACTURE MECHANICS
B24ME4P43	PRESSURE VESSEL AND PIPING DESIGN
B24ME4P44	FUNDAMENTALS OF UNMANNED AERIAL VEHICLES (UAV)
B24ME4P45	REFRIGERATION AND CRYOGENICS
B24ME4P46	HEAT TRANSFER EQUIPMENT DESIGN
B24ME4P47	ADVANCED NON DESTRUCTIVE TESTING
B24ME4P48	MEMS AND NANOTECHNOLOGY
B24ME4P49	ADVANCED NUMERICALLY CONTROLLED MACHINING

OPEN ELECTIVE II

B24ME4G21	INTRODUCTION TO BUSINESS ANALYTICS
B24ME4G22	PATENTS AND INTELLECTUAL PROPERTY RIGHTS
B24ME4G23	FUNDAMENTALS OF LOGISTICS AND SUPPLY CHAIN MANAGEMENT
B24ME4G24	RENEWABLE ENERGY ENGINEERING
B24ME4G25	INTRODUCTION TO 3D PRINTING
B24ME4G26	FUNDAMENTALS OF COMPOSITE MATERIALS
B24ME4G27	INTRODUCTION TO ACOUSTICS AND NOISE CONTROL

B24ME4T01	PROJECT MANAGEMENT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces the fundamental concepts and techniques used in the planning, evaluation, and management of engineering projects. It covers project identification, feasibility analysis, manufacturing project design, cost estimation, and investment evaluation. Students will also learn the application of project screening tools such as SWOT Analysis and BCG Matrix, along with financial and risk analysis methods. The course further includes project scheduling and control using techniques such as Critical Path Method and Program Evaluation and Review Technique to support effective decision-making in engineering project management.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the concepts of engineering projects, project life cycle, project planning and feasibility analysis including strategic screening tools such as SWOT Analysis and BCG Matrix. (Cognitive Knowledge Level: Understand)
CO 2	Apply principles of manufacturing project design for selecting plant location, plant layout, production capacity, and estimating project costs. (Cognitive Knowledge Level: Apply)
CO 3	Apply capital budgeting techniques such as Net Present Value, Internal Rate of Return, and payback period to evaluate engineering investment decisions. (Cognitive Knowledge Level: Apply)
CO 4	Apply financial planning and risk assessment tools including break-even analysis, sensitivity analysis, and inventory models such as Economic Order Quantity in project planning. (Cognitive Knowledge Level: Apply)
CO 5	Apply network techniques such as Critical Path Method and Program Evaluation and Review Technique to schedule, monitor, and control engineering projects. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	20	20
Understand	40	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Project Planning and Feasibility Analysis (7 Hours)

Introduction to engineering projects – characteristics and classification of projects – project life cycle and stages of project development – project organization structures – principles of project planning and control – identification of project opportunities – strategic considerations in project selection – preliminary screening of project ideas using appropriate strategic analysis tools – project formulation and feasibility analysis – demand analysis and forecasting – market survey and marketing considerations in industrial projects – preparation of feasibility reports.

MODULE 2: Manufacturing Project Design and Cost Estimation (7 Hours)

Manufacturing process selection and technology considerations – product mix and production capacity planning – selection of plant location and site factors – plant layout considerations for manufacturing projects – selection of plant and machinery – project implementation stages – project scheduling and coordination of project activities – estimation of project cost including land, buildings, machinery, utilities and working capital – sources of finance for industrial projects.

MODULE 3: Investment Evaluation and Capital Budgeting (7 Hours)

Concept of capital investment decisions – phases of capital budgeting – principles of project cash flow estimation – time value of money – investment evaluation techniques: payback period, accounting rate of return, net present value (NPV), benefit–cost ratio and internal rate of return (IRR) – comparison of investment criteria – selection among alternative projects – project cash flow estimation issues and biases.

MODULE 4: Project Risk and Financial Planning (7 Hours)

Sources of risk in industrial projects – risk identification and assessment – break-even analysis – scenario analysis and sensitivity analysis – risk management strategies in project planning – project financing concepts – capital structure and debt–equity ratio – sources of finance including equity, loans and institutional finance – basics of working capital management – inventory management concepts and Economic Order Quantity – introduction to Just-in-Time systems.

MODULE 5: Project Scheduling and Control Techniques (8 Hours)

Network techniques in project management – development of project networks – rules for network construction – time estimation in project activities – Critical Path Method – Program Evaluation and Review Technique – project scheduling with resource constraints – monitoring and control of projects – project review and post-audit – project abandonment and divestment decisions – case studies in engineering project management.

Text Books

1. Prasanna Chandra. *Project: Planning, Implementation and Review*. Tata McGraw Hill, New Delhi.
2. Harold Kerzner – *Project Management: A Systems Approach to Planning, Scheduling and Controlling,* John Wiley & Sons.
3. Pouliquen L. Y., *Risk analysis in Project Appraisal,* Johns Hopkins Press, Baltimore, California.
4. Rajiv Srivastava and Anil Misra, *Financial Management*, Oxford University Press, New Delhi.

Reference Books

1. Amran M and N. Kulatilalka, *Managing strategic investment in Uncertain world*. Harvard Business school press, Boston 2000.
2. Reghuram G *Infrastructure development and financing*, Macmillan India, Delhi, 1999
3. Weingartner, M.H., *Mathematical programming and Analysis of capital budgeting problems,* Prentice-Hall, Englewood Cliffs, N.J, 1963.
4. Weist, J.D, and F, K. Levy, *A management Guide to PERT/CPM*, Prentice-Hall of India, New Delhi.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Introduction to engineering projects – characteristics and classification – project life cycle – stages of project development – project organization structures	2
1.2	Principles of project planning and control – identification of project opportunities – strategic considerations – screening of project ideas using SWOT Analysis and BCG Matrix etc.	2
1.3	Project formulation and feasibility analysis – demand analysis and forecasting – market survey – preparation of feasibility reports	3
	Module 2	**7**
2.1	Manufacturing process selection – technology considerations – product mix and production capacity planning	2
2.2	Plant location and site selection factors – plant layout considerations	2
2.3	Selection of plant and machinery – project implementation stages – estimation of project cost – sources of finance	2
2.4	Sources of finance	1
	Module 3	**7**
3.1	Concept of capital investment decisions – phases of capital	2

	budgeting – project cash flow estimation – time value of money	
3.2	Investment evaluation techniques: payback period – accounting rate of return – Net Present Value	3
3.3	Benefit–cost ratio – Internal Rate of Return – comparison of investment criteria – selection among alternative projects	2
	Module 4	**7**
4.1	Sources of risk in industrial projects – risk identification and assessment	2
4.2	Break-even analysis – scenario analysis – sensitivity analysis	2
4.3	Project financing concepts – capital structure – working capital management – inventory management including Economic Order Quantity – introduction to JIT	3
	Module 5	**8**
5.1	Introduction to project scheduling – development of project networks – rules for network construction	2
5.2	Time estimation in project activities – Critical Path Method – Program Evaluation and Review Technique	3
5.3	Project scheduling with resource constraints – monitoring and control – project review and post audit – project abandonment and case studies	3
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1)

1. What is meant by the project life cycle? List its major stages.
2. Distinguish between project planning and project control.
3. Explain the stages of the project life cycle and discuss their importance in engineering projects.
4. Discuss the process of project identification, screening, and feasibility analysis in industrial project planning.

Course Outcome 2 (CO2)

1. Explain Plant capacity, Product mix, Location and Site? Describe the important charts and layout drawings?
2. Mention different sources of finance for industrial projects.
3. Explain the factors influencing plant location and discuss suitable methods for selecting plant sites.
4. Discuss the stages involved in project implementation and coordination of project activities.

Course Outcome 3 (CO3)

1. What is NPV, IRR, Payback period? Explain the properties of the NPV rule?
2. What is meant by time value of money?
3. What is UNIDO approach and Social Cost Benefit Analysis? Detail about multiple projects and constrains?
4. A project requires an initial investment of ₹2,00,000 and generates cash inflows of ₹70,000 per year for 5 years. If the discount rate is 10%, calculate the NPV and state whether the project should be accepted.

Course Outcome 4 (CO4)

1. Define Economic Order Quantity?
2. Explain different sources of risk in industrial projects and methods for risk assessment.
3. What are the different sources of finances and working capital? Describe about Credit risk rating and Private public partnership?
4. Describe the essence of Inventory Management? What is Economic order quantity and Just in time?

Course Outcome 5 (CO5)

1. What is a project network?
2. D Describe the Critical Path Method (CPM) and explain how the critical path is identified in a project network?
3. Explain network techniques and time estimations? Explain PERT and CPM.
4. What are the pre-requisites for successful project implementation, explain? Detail about abandonment analysis, managing divestments?

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4T01**

Course Name: **PROJECT MANAGEMENT**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1	What is demand forecasting? Why is it important in project formulation?
2	Explain the preliminary screening of project ideas?
3	What are the typical stages of project implementation?
4	Mention different sources of finance for industrial projects.
5	Differentiate between Net Present Value and Internal Rate of Return?
6	Define capital budgeting.?
7	Identify the key factors in determining the Debt-Equity ratio?
8	Detail about the different types of costs in Inventory Management?
9	What is project monitoring and control?
10	Explain Network techniques for project management?

PART B

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

Module 1

11	a.	Discuss the process of project identification, screening, and feasibility analysis in industrial project planning.	(7 marks)
	b.	What are the different techniques used for demand forecasting	(7 marks)

OR

12 a. Detail about Project planning? What are the different **f**orms of project organization? (7 marks)

b. How are different strategies formulated? Differentiate between grand strategy and portfolio strategy? (7 marks)

Module 2

13 Discuss in detail about Plant capacity? Detail about the factors for selecting Plant location? (14 marks)

OR

14 Explain the procedure for estimating project cost including land, building, machinery, and working capital? (14 marks)

Module 3

15 a. What are the Investment Criteria? Describe NPV and IRR and properties of the NPV rule. (7 marks)

b. Explain the concept and phases of capital budgeting in project evaluation? (7 marks)

OR

16 a. Discuss different investment evaluation techniques with advantages and limitations? (8 marks)

b. Calculate the different measures of Risk for the capital investment of a company ABC. The NPV value and distribution are given in the table.

Sl. No	NPV	Probability
1	200	0.3
2	600	0.5
3	900	0.2

(6 marks)

Module 4

17 What is significance of Capital structure? Detail about the key factors in determining the Debt-Equity rat (14 marks)

OR

18 a. Explain project financing concepts, capital structure, and sources of finance for industrial projects? (8 marks)

b. Daily consumption rate of a product in a company is 400 units. Cost of each unit is Rs 6 and inventory carrying cost is Rs 2.5. Cost of placing an order is Rs. 500. Assume 300 working days in a year. Calculate EOQ, Cycle time and Annual inventory capital? (6 marks)

Module 5

19 a. Explain PERT and CPM? Discus the rules for the construction of Network Diagram? (7 marks)

b Why post audit be done? What is abandonment analysis? (7 marks)

OR

20 A project consisting of 12 activities and their time activities are shown

Activity.	**Time (in weeks)**		
	to	tm	tp
1-2	4	6	9
1-3	3	8	12
1-4	5	5	8
1-7	2	4	6
2-4	6	10	18
2-6	3	4	7
2-7	5	10	16
3-4	3	6	11
4-5	2	4	6
5-6	1	3	7
3-7	2	4	8
6-7	1	2	6

a) Draw the Network diagram.

b) Determine the Critical path.

c) Calculate event slacks and activity floats.

(14 marks)

B24ME4P31	PRODUCT DESIGN AND DEVELOPMENT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The course aims to develop creativity, analytical ability, and confidence in designing innovative products. It introduces students to systematic methods, tools, and strategies used in product design and development. The course emphasizes integration of conceptualization, design thinking, engineering principles, manufacturing considerations, and economic evaluation to transform ideas into technically feasible, user-centered, and market-viable products.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the life cycle of a product and the product development process. (Cognitive Knowledge Level: Understand)
CO 2	Apply robust design and conceptual design principles in product development. (Cognitive Knowledge Level: Apply)
CO 3	Explain the principles of Design for Manufacturing and Assembly in product design. (Cognitive Knowledge Level: Understand)
CO 4	Apply value engineering techniques in product development. (Cognitive Knowledge Level: Apply)
CO 5	Demonstrate the integration of concurrent engineering, rapid prototyping, and reverse engineering concepts in developing innovative product solutions. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	2	2	1	–	–	–	–	–	1	–	1
CO 2	3	2	3	1	2	–	–	–	–	1	–
CO 3	2	2	3	–	1	2	–	–	–	1	–
CO 4	2	3	3	1	2	2	–	–	–	2	–
CO 5	2	2	3	2	3	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	60	60	40
Apply	20	20	40
Analyse			
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts: Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Fundamentals of Product Design and Development Process (7 hours)

Introduction: Classification and Specifications of Products, Product life cycle, product mix. Introduction to product design, Modern product development process. Design by evolution, Design by innovation, Morphology of design -Development Processes: A generic development process, concept development: the front-end process, product development process flow.

MODULE 2: Creativity, Conceptual Design, and Robust Design (7 hours)

Creativity Techniques: Creative thinking, conceptualization, brainstorming, primary design, drawing, simulation, and detail design - Conceptual Design: Generation, selection & embodiment of concept- Product architecture- Industrial design: process, need- Robust Design: Taguchi Designs, Design of Experiments.

MODULE 3: Design for X (DFX) and Human-Centered Product Design (7 hours)

Design for Manufacturing and Assembly: Methods of designing for Manufacturing and Assembly- Design for Maintenance. Design for Environment - Ergonomics in product design - Aesthetics in product design. Concepts of size, texture, and color.

MODULE 4: Value Engineering and Economic Considerations in Design (7 hours)

Value Engineering / Value Analysis: Definition. Methodology, Case studies.

Product costing- Economic analysis: Qualitative & Quantitative - Psychological and Physiological Considerations.

MODULE 5: Advanced Product Development Technologies and Tools (8 hours)

Concurrent Engineering -Elements of concurrent engineering, Benefits - Rapid prototyping: concepts, processes, and advantages - Reverse engineering: steps in reverse engineering-hardware and software in reverse engineering - Tools for product design – Drafting / Modeling software - Patents & IP Acts. Overview, Disclosure preparation.

Text Books

1. Karl T Ulrich, Steven D Eppinger, *Product Design & Development*, Tata McGraw-Hill.
2. George E Deiter, *Engineering Design*, McGraw-Hill.

Reference Books

1. Bralla J G (Ed.), *Handbook of Product Design for Manufacture*, McGraw Hill, NewYork.
2. David G Ullman, *The Mechanical Design Process*, McGraw Hill Inc Singapore.
3. Hollins B & Pugh S, *Successful Product Design*, Butter worths London.
4. Jones J C, *Design Methods: Seeds of Human Futures*, John Willey.
5. Kevin Otto & Kristin Wood, *Product Design: Techniques in Reverse Engineering and new Product Development*, Pearson Education New Delhi.
6. N J M Roozenberg, J Ekels, N F M Roozenberg, *Product Design Fundamentals and Methods*, John Willey & Sons.

7. Boothroyd, G., Dewhurst, P. and Knight, W., Product Design for Manufacture and Assembly, CRC Press.
8. Ashby, M.F., Materials Selection in Mechanical Design, Butterworth-Heinemann.
9. Gibson, I., Rosen, D.W., & Stucker, B., Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Springer.
10. Awari, G.K., Thorat, C.S., Ambade, V., & Kothari, D.P., Additive Manufacturing and 3D Printing Technology: Principles and Applications, 1st Ed., CRC Press / Taylor & Francis.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Introduction: Classification/ Specifications of Products- PLC	2
1.2	Product mix. Introduction to product design. Modern product development process. Design by evolution, Design by innovation, Morphology of design.	2
1.3	Innovative thinking. Morphology of design.	1
1.4	Development Processes: generic development process, concept development-front-end process, product development process flow.	2
	Module 2	**7**
2.1	Creativity Techniques: Creative thinking, conceptualization, brainstorming, primary design, drawing, simulation, detail design.	2
2.2	Conceptual Design: Generation, selection & embodiment of concept, Product architecture.	2
2.3	Industrial design: process, need.	1
2.4	Robust Design: Taguchi Designs, Design of Experiments.	2
	Module 3	**7**
3.1	Design for Manufacturing and Assembly: Methods of designing for Manufacturing and Assembly.	2
3.2	Design for Maintenance. Design for Environment.	2
3.3	Ergonomics in product design.	1
3.4	Aesthetics in product design. Concepts of size, texture, and color.	2
	Module 4	**7**
4.1	Value Engineering / Value Analysis: Definition. Methodology, Case studies. Product costing.	3
4.2	Economic analysis: Qualitative & Quantitative.	2
4.3	Psychological and Physiological Considerations.	2
	Module 5	**8**
5.1	Concurrent Engineering -Elements -Benefits	2
5.2	Rapid prototyping: concepts, processes, and advantages.	2
5.3	Reverse engineering: steps in reverse engineering- hardware and software in reverse engineering.	1
5.4	Tools for product design – Drafting / Modeling software.	2
5.5	Patents & IP Acts. Overview, Disclosure preparation.	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Analyse the steps and responsibilities involved in the development of a new product with the help of an example?
2. Define the Product Development Process and explain the various phases of the generic development process.
3. With the help of examples explain the design by evolution and design by innovation approach.

Course Outcome 2 (CO2):

1. Explain the various processes involved in the Industrial Design.
2. What is meant by Product Architecture? Describe the steps involved in Product Architecture?
3. Interpret embodiment of concept in product design with suitable example.

Course Outcome 3 (CO3):

1. Show the design of a simple sofa and then depict how the design changes when considering 1) aesthetics and 2) ergonomics into consideration. Give hand sketches and explanations to justify the changes in designs.
2. Design a chair for a computer operator based on the ergonomic aspect.
3. Discuss the impact of manufacturing industry in environment and how it can be minimized.

Course Outcome 4 (CO4):

1. Explain the concept of Value Engineering. Discuss with suitable case studies.
2. Describe the how to estimate the cost of a particular design using ANY of the following: i) a website, ii) the layout of a plant, iii) the elevation of a building, iv) an electrical or electronic system or device and v) a car. Show how economics will influence the engineering designs. Use hand sketches to support your arguments.
3. Explain the role of physiological considerations in product design.

Course Outcome 5 (CO5)

1. Discuss briefly reverse engineering approach in product design. What are its advantages?
2. List out the classification of rapid prototyping (RP) technology? Illustrate any two types of RP applications with the help of sketches.
3. Apply the concept of reverse-engineering in the development of a product with the help of an example.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4P31**

Course Name: **PRODUCT DESIGN AND DEVELOPMENT**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1	Explain the term product mix in product design with a suitable example.
2	Explain 'Product Life Cycle' of a manufactured product.
3	Demonstrate parameter diagram used in robust design with the help of examples.
4	What is the need for a Conceptual Design in the product design process.
5	Explain the term anthropometry and elaborate on the importance of anthropometry in ergonomics.
6	List the merits of Design for Manufacturing and Assembly (DFMA).
7	Differentiate between quantitative and qualitative economic analysis.
8	List the benefits and drawbacks of value engineering?
9	Outline the role of modelling software in product design.
10	List out the steps involved in the preparation of a patent disclosure.

PART B

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

Module 1

11	a.	Analyze the steps involved in the development of a new product with the help of an example?	(7 marks)
	b.	With the help of a neat sketch explain the Product Life Cycle.	(7 marks)

OR

12	With the help of examples explain the design by evolution and design by innovation approach.	(14 marks)

Module 2

13 What is meant by Product Architecture? Describe the steps involved in Product Architecture? (14 marks)

OR

14 What do you mean by Industrial Design and the steps involved in the industrial design process. (14 marks)

Module 3

15 a. What are the similarities and differences of DFA (Design for Assembly) and DFM (Design for Manufacturing)? (7 marks)

b. Design a chair for a computer operator based on the ergonomic aspect. (7 marks)

OR

16 a. Discuss the impact of manufacturing industry in environment and how it can be minimized. (7 marks)

b. How does the ergonomics and aesthetics aspect influence the product design? (7 marks)

Module 4

17 Explain the concept of Value Engineering. Discuss with suitable case studies. (14 marks)

OR

18 Explain the use of FAST diagram in value engineering. What are its advantages? (14 marks)

Module 5

19 Discuss briefly reverse engineering approach in product design. What are it advantages? (14 marks)

OR

20 List out the classification of rapid prototyping (RP) technology? Illustrate any two types of RP applications with the help of sketches. (14 marks)

B24ME4P32	ADVANCED DESIGN SYNTHESIS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The study of mechanisms forms a fundamental part of mechanical engineering, providing the basis for analysing and designing systems that produce controlled motion. This course offers an overview of techniques used in the analysis and synthesis of mechanisms, emphasising both graphical and analytical approaches. It aims to provide a solid theoretical foundation to understand modern mechanism design methodologies while fostering the ability to apply these principles in practical engineering contexts. Students will learn to identify various types of mechanisms based on their motion characteristics, such as planar and spatial mechanisms, and to select and dimension appropriate mechanisms for specific applications using fundamental synthesis techniques.

Prerequisites

Theory of Machines

Course Outcomes

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

CO 1	Apply advanced kinematic methods to analyze velocity, acceleration, and motion in mechanisms. (Cognitive Knowledge Level: Apply)
CO 2	Solve the synthesis of slider crank mechanism with three accuracy points (Cognitive Knowledge Level: Apply)
CO 3	Explain the synthesis of slider crank mechanism with four accuracy points (Cognitive Knowledge Level: Understand)
CO 4	Describe the algebraic methods of synthesis using displacement equations (Cognitive Knowledge Level: Understand)
CO 5	Apply the principles of rectilinear mechanisms and spatial linkages to analyze and synthesize single-loop and multiple-loop spatial mechanisms, and evaluate their applications in simple robotic systems. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	20	30	10
Understand	40	70	40
Apply	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Advanced Kinematic Analysis of Mechanisms (8 hours)

Floating Link, Special methods of velocity and acceleration analysis using auxiliary points. Overlay method for conditioned crank mechanisms, coupler curves. Roberts – Chebyshev theorem. Inflection circle, Euler- Savery equation, Hartman construction.

MODULE 2: Geometric Synthesis of Mechanisms with Three Precision Points (7 hours)

Synthesis using Optimum transmission angle. Geometric methods of synthesis with three accuracy points: - poles of four bar linkages, Function generators, poles of slider crank mechanisms, Relative poles of slider crank Mechanisms, Synthesis of slider crank mechanism with three accuracy points.

MODULE 3: Geometric Synthesis of Mechanisms with Four Precision Points (8 hours)

Geometric methods of synthesis with four accuracy points: - pole triangles, center point curves, Circle point curves, Construction of circle points, Cardinal points, opposite poles, Pole quadrilaterals, Function Generators, Synthesis of slider crank mechanism with four accuracy points.

MODULE 4: Algebraic Synthesis Using Displacement Equations (6 hours)

Algebraic methods of synthesis using displacement equations: - Crank and follower synthesis- three accuracy points. Crank and follower synthesis- angular velocities and accelerations.

MODULE 5: Spatial Mechanisms and Robotic Linkages (7 hours)

Rectilinear mechanisms, Spatial motion and spatial linkages, Types of spatial mechanisms, Single loop linkage and multiple loop linkages. Simple mechanisms in robots.

Introduction to mechanism synthesis and motion simulation using software MSC ADAMS.

Text Books

1. Richard S. Hartenberg, Jacques Denavit, *Kinematic synthesis of Linkages* McGraw Hill book company.
2. Allen S. Hall, *Kinematics and linkage design,* Prentice Hall of India, Ltd.
3. Shigley, *Theory of Mechanisms and Machines*, McGraw Hill International Edition.

Reference Books

1. A. R. Holowenko, *Dynamics of Machinery,* John Wiley & Sons Inc.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**8**
1.1	Floating Link, Special methods of Velocity and Acceleration Analysis using auxiliary points.	2
1.2	Overlay method for conditioned crank mechanisms, coupler curves. Roberts – Chebyshev theorem	2
1.3	Inflection circle, Euler- Savery equation, Hartman construction	2
1.4	Synthesis using Optimum transmission angle	2
	Module 2	**7**
2.1	Geometric methods of synthesis with three accuracy points: - poles of four bar linkages.	2
2.2	Relative poles of four bar linkages, Function generators, poles of slider crank mechanisms	2
2.3	Relative poles of slider crank Mechanisms	1
2.4	Synthesis of slider crank mechanism with three accuracy points	2
	Module 3	**8**
3.1	Geometric methods of synthesis with four accuracy points: - pole triangles, center point curves	2
3.2	Circle point curves, Construction of circle points.	2
3.3	Cardinal points, opposite poles, Pole quadrilaterals,	2
3.4	Synthesis of slider crank mechanism with four accuracy points.	2
	Module 4	**6**
4.1	Algebraic methods of synthesis using displacement equations	2
4.2	Crank and follower synthesis- three accuracy points	2
4.3	Crank and follower synthesis- angular velocities and accelerations	2
	Module 5	**7**
5.1	Rectilinear mechanisms, Spatial motion and spatial linkages	3
5.2	Types of spatial mechanisms, Single loop linkage	2
5.3	**Multiple loop linkages. Simple mechanisms in Robots,** Introduction to mechanism synthesis and motion simulation using software MSC ADAMS	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Calculate Velocity and Acceleration Analysis of complex mechanisms using auxiliary points.
2. Describe Roberts – Chebyshev theorem.
3. Explain the Inflection circle, Euler- Savery equation, and Hartman construction.

Course Outcome 2 (CO2):

1. Describe the relative poles of four-bar linkages and slider crank mechanisms.
2. List out the usage of Function generators.
3. Execute the synthesis of the slider crank mechanism with three accuracy points.

Course Outcome 3 (CO3):

1. Execute the geometric methods of synthesis with four accuracy points.
2. Discuss the construction of circle points, cardinal points, opposite poles, and Pole quadrilaterals.
3. Do the synthesis of the slider crank mechanism with four accuracy points.

Course Outcome 4 (CO4):

1. Demonstrate the algebraic methods of synthesis using displacement equations.
2. Execute the Crank and follower synthesis.
3. Describe the method to get angular velocities and accelerations from crank and follower synthesis.

Course Outcome 5 (CO5)

1. Discuss Rectilinear mechanisms.
2. Explain the importance of spatial motion and spatial linkages.
3. Demonstrate the working of the Simple mechanisms in Robots.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: B24ME4P32

***Course Name:* ADVANCED DESIGN SYNTHESIS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 State and explain the Robert Chebychev theorem.

2 Explain the properties of inflection circle.

3 What are three accuracy points in cam and follower synthesis?

4 Explain the relative poles of the slider crank mechanism with a sketch.

5 What is the significance function generator in the design of a mechanism?

6 Explain the pole quadrilateral in geometric synthesis.

7 Define the centre point and circle point.

8 Write notes on types of errors in synthesis.

9 Draw a simple robot mechanism.

10 Classify the various types of spatial mechanisms.

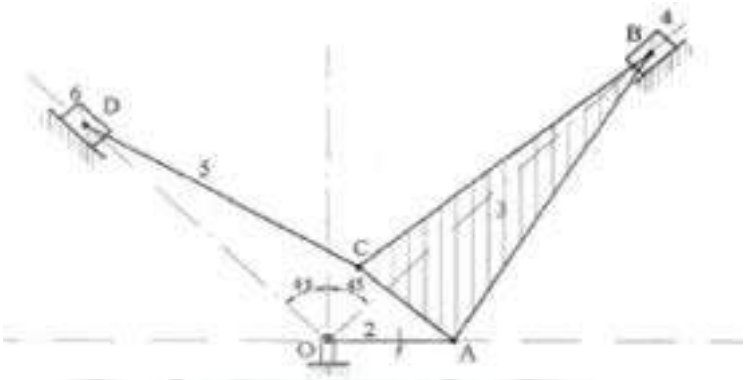
PART B

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

Module 1

11 For the twin cylinder V engine, determine the velocity of pistons B and D and the angular velocity of link 3. Link 2 rotates at 2000rpm. The dimensions of the various links are: O2A = 50mm ; AB = BC = 150mm ; AC =50mm ; CD = 125mm.

(14 marks)



OR

12 Using overlay method and Chebyshev spacing, design a four-bar mechanism to generate the function $y = x^{1.5}$ for $0.5 < x < 1.5$. Assume six precision points. (14 marks)

Module 2

13 a. Discuss the significance of transmission angle in the design of a four-bar mechanism. (6 marks)

b Explain the procedure for designing a four-bar mechanism for optimum transmission angle. (8 marks)

OR

14 Design a function generator linkage to solve $y = 1/x$ in the range $1 < x < 2$ using three precision points, using the geometric method. $\Delta\Phi = 90^o$, $\Delta\Psi = 90^o$, $\Phi_0 = 90^o$, $\Psi_0 = 45^o$. Plot a curve of the desired function and the one generated by the synthesised linkage, and find the maximum error percentage. (14 marks)

Module 3

15 Design a slider crank mechanism such that $\Phi_{12} = 30^o$ and $\Phi_{23} = 50^o$ and $S_{12} = 25$ cm and S23 = 20 cm using geometric method. The input crank moves in a clockwise direction, and the slider moves away from the crank pivot. (14 marks)

OR

16 Design a double rocker mechanism to generate the function $y = e^x$ in the range $1 \leq x \leq 1$ using four precision points and Chebychev spacing using the geometric method. (14 marks)

Module 4

17 Synthesise a four-bar generator to generate the function $y = \log_{10} x$ in the range $1 \leq x \leq 2$ using algebraic method. Assume suitable starting angles and ending angles for the motion of the input and output links. Use three precision points and Chebychev spacing. Find out the maximum error. (14 marks)

OR

18 Synthesise a four-bar linkage to meet the following specification of position, velocity and acceleration. $\Phi = 60^o$, $\Psi = 90^o$, $\omega_\Phi = 5$ rad/s, $\omega_\Psi = 2$ rad/s, $\alpha_\Phi = 2$ rad/s^2, $\alpha_\Psi = 7$ rad/s^2 (14 marks)

Module 5

19 Explain rectilinear mechanisms and spatial motion in detail. (14 marks)

OR

20 Discuss spatial linkages, their types, and simple mechanisms used in robots. (14 marks)

B24ME4P33	INDUSTRIAL TRIBOLOGY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Tribology, the science of friction, wear, and lubrication, plays a critical role in the reliable and efficient operation of industrial machinery. This elective course provides students with a practical understanding of tribological principles and their applications in real-world industrial systems. Emphasis is placed on friction and wear mechanisms, lubrication fundamentals, surface protection techniques, and maintenance practices. Students will also be introduced to emerging trends and sustainable practices, including eco-friendly lubricants, energy-efficient machinery operation, and condition-based maintenance strategies. Through this course, students will gain the knowledge and skills necessary to analyze, prevent, and mitigate tribological failures, thereby improving machine reliability, reducing maintenance costs, and promoting sustainable industrial practices.

Prerequisite

Nil

Course Outcomes

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

CO 1	Describe the basic principles of tribology, including friction, wear, and lubrication, and explain the influence of surface and material properties on machine components. (Cognitive Knowledge Level: Understand)
CO 2	Explain the mechanisms of friction and different types of wear in industrial components, and apply suitable practices to reduce wear in machinery. (Cognitive Knowledge Level: Apply)
CO 3	Explain lubrication regimes, lubricant properties, and selection criteria, and apply lubrication principles in industrial components and maintenance practices. (Cognitive Knowledge Level: Apply)
CO 4	Summarize various surface protection techniques, industrial maintenance practices, and methods used to reduce wear and improve reliability of mechanical systems. (Cognitive Knowledge Level: Understand)
CO 5	Illustrate practical industrial applications of tribology, identify common failures, and outline emerging trends and sustainable practices in lubrication and machinery maintenance. (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	1	–	1	1	–	–	–	–	1
CO 2	3	2	3	1	2	1	–	–	–	–	1
CO 3	3	2	3	1	3	2	–	–	–	1	1
CO 4	2	2	2	–	2	2	–	–	–	1	1
CO 5	2	2	3	1	3	3	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	60	60	40
Apply	20	20	40
Analyse			
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 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) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Introduction to Tribology (8 hours)

Definition, scope, and history of tribology, Friction, wear, and lubrication concepts, Importance of tribology in engineering and industrial applications, Examples of tribological failures in machines (engines, bearings, gears).

Surface roughness and measurement techniques (profilometry, tactile methods), Surface topography and its effect on friction and wear, Material properties affecting tribology: hardness, toughness, elasticity, Importance of surface finish and surface treatments in industry

MODULE 2: Friction and Wear in Machines (8 hours)

Classical laws of friction, Types of friction: static, sliding, rolling, Friction in industrial components: bearings, brakes, belts, clutches.

Adhesive, abrasive, fatigue, and corrosive wear, Factors influencing wear in industrial machinery, Wear measurement methods: pin-on-disc, block-on-ring, Preventive practices to reduce wear in machines.

MODULE 3: Fundamentals of Lubrication (7 hours)

Purpose of lubrication and types of lubrication: boundary, mixed, hydrodynamic, Viscosity and its role in lubrication, Stribeck curve, Common industrial lubricants and their selection criteria.

Lubrication of bearings, gears, cams, and sliding surfaces, Lubrication schedules and maintenance practices in industry, Additives in industrial lubricants: anti-wear, extreme pressure, corrosion inhibitors, Analysis of lubrication failures.

MODULE 4: Surface Protection and Industrial Practices (6 hours)

Surface coatings: hard chrome, nickel plating, enamel coatings, Brief introduction to surface treatments: nitriding, carburizing, Role of coatings in reducing wear and friction.

Condition-based maintenance and lubrication scheduling, Monitoring and inspection techniques for industrial machinery, Case studies of industrial tribological failures and preventive actions.

MODULE 5: Industrial Applications and Emerging Trends in Tribology (7 hours)

Tribology in automotive systems: engines, gearboxes, bearings, brakes, Tribological aspects in manufacturing equipment: cutting tools, dies, presses, conveyors, rollers, Applications in power plants: turbines, pumps, compressors, Common tribological failures in industry and their root causes, Role of proper lubrication and maintenance in improving machine reliability.

Introduction to eco-friendly and biodegradable lubricants, Energy efficiency improvement through friction reduction, Surface texturing for improved lubrication performance, Use of advanced coatings for longer service life, Sustainable maintenance practices, and waste lubricant management.

Text Books

1. S. K. Basu, S. N. Sengupta, and B. B. Ahuja, *Fundamentals of Tribology*. PHI Learning Pvt. Ltd.
2. P. Sahoo, *Engineering Tribology*. PHI Learning Pvt. Ltd.

3. T. V. V. L. N. Rao, S. Binti Kasolang, G. Xie, J. K. Katiyar, and A. M. A. Rani, *Green Tribology: Emerging Technologies and Applications, Emerging Materials and Technologies.* CRC Press.

Reference Books

1. G. W. Stachowiak and A. W. Batchelor, *Engineering Tribology*, 4th ed. Butterworth-Heinemann.
2. I. Hutchings and P. Shipway, *Tribology: Friction and Wear of Engineering Materials*, 2nd ed., Butterworth-Heinemann.
3. B. Bhushan, *Introduction to Tribology*, 2nd ed. Wiley & Sons, Ltd.
4. P. J. Blau, *Friction Science and Technology: From Concepts to Applications*, 2nd ed. CRC Press / Taylor & Francis.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module1	**8**
1.1	Definition, scope, and history of tribology	1
1.2	Friction, wear, and lubrication concepts	1
1.3	Importance of tribology in engineering and industrial applications	1
1.4	Examples of tribological failures in machines (engines, bearings, gears).	1
1.5	Surface roughness and measurement techniques (profilometry, tactile methods)	1
1.6	Surface topography and its effect on friction and wear	1
1.7	Material properties affecting tribology: hardness, toughness, elasticity	1
1.8	Importance of surface finish and surface treatments in industry	1
	Module 2	**8**
2.1	Classical laws of friction	1
2.2	Types of friction: static, sliding, rolling	1
2.3	Friction in industrial components: bearings, brakes, belts, clutches.	2
2.4	Adhesive, abrasive, fatigue, and corrosive wear	1
2.5	Factors influencing wear in industrial machinery	1
2.6	Wear measurement methods: pin-on-disc, block-on-ring	1
2.7	Preventive practices to reduce wear in machines.	1
	Module 3	**7**
3.1	Purpose of lubrication and types of lubrication: boundary, mixed, hydrodynamic	1
3.2	Viscosity and its role in lubrication, Stribeck curve	1
3.3	Common industrial lubricants and their selection criteria	1
3.4	Lubrication of bearings, gears, cams, and sliding surfaces	1
3.5	Lubrication schedules and maintenance practices in industry	1

3.6	Additives in industrial lubricants: anti-wear, extreme pressure, corrosion inhibitors	1
3.7	Analysis of lubrication failures.	1
	Module 4	**6**
4.1	Surface coatings: hard chrome, nickel plating, enamel coatings	1
4.2	Brief introduction to surface treatments: nitriding, carburizing	1
4.3	Role of coatings in reducing wear and friction	1
4.4	Condition-based maintenance and lubrication scheduling	1
4.5	Monitoring and inspection techniques for industrial machinery	1
4.6	Case studies of industrial tribological failures and preventive actions	1
	Module 5	**7**
5.1	Tribology in automotive systems: engines, gearboxes, bearings, brakes	1
5.2	Tribological aspects in manufacturing equipment: cutting tools, dies, presses, conveyors, rollers,	1
5.3	Applications in power plants: turbines, pumps, compressors,	1
5.4	Common tribological failures in industry and their root causes, Role of proper lubrication and maintenance in improving machine reliability	1
5.5	Introduction to eco-friendly and biodegradable lubricants	1
5.6	Energy efficiency improvement through friction reduction. Surface texturing for improved lubrication performance,	1
5.7	Use of advanced coatings for longer service life, Sustainable maintenance practices, and waste lubricant management.	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the significance of lubrication in engineering applications and machine reliability.
2. Discuss the influence of surface roughness and topography on frictional behavior and wear performance of machine components.
3. Explain how material properties such as hardness, toughness, and elasticity affect tribological performance.

Course Outcome 2 (CO2):

1. Summarize the classical laws and types of friction.
2. Discuss the major wear mechanisms.
3. Explain the methods used for wear measurement.

Course Outcome 3 (CO3):

1. Explain the different lubrication regimes using the Stribeck curve.

2. Discuss the selection criteria of industrial lubricants.
3. Explain how maintenance practices and lubrication schedules help in preventing machine breakdown.

Course Outcome 4 (CO4):

1. Discuss the role of surface coatings in reducing friction and wear.
2. Explain condition-based maintenance and lubrication scheduling practices.
3. Explain how monitoring techniques enhance machine reliability.

Course Outcome 5 (CO5):

1. Discuss the application of tribology in different fields and operational challenges.
2. Explain the role of lubrication and maintenance in improving reliability and service life.
3. Explain the emerging sustainable practices in the field of tribology.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER BTECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4P33**

Course Name: **INDUSTRIAL TRIBOLOGY**

Max. Marks: 100 Duration: 3 hours

(Any missing data may be assumed appropriately.)

PART A

Answer all questions. Each question carries 3 marks.

1. List the different types of wear and mention one practical example for each.
2. What is surface roughness? Name two commonly used roughness parameters.
3. Differentiate between static friction and sliding friction.
4. What is the purpose of a pin-on-disc wear test?
5. What is viscosity? Why is it important in lubrication?
6. List common additives used in industrial lubricants and state their functions.
7. Differentiate between carburizing and nitriding.
8. Mention two monitoring techniques used in industrial machinery inspection.
9. List common root causes of tribological failures in turbines or compressors.
10. What is surface texturing and how does it improve lubrication performance?

PART B

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

Module 1

11. Define Tribology. Explain the three primary components of tribology and describe how their study contributes to the reliability and energy efficiency of modern mechanical systems. (14 marks)

OR

12. Explain the influence of surface roughness and topography on friction and wear. Discuss the different parameters used to specify surface roughness. (14 marks)

Module 2

13. Summarize the classical laws and types of friction. Discuss their role in the functioning and efficiency of components such as bearings, brakes and belts.(14 marks)

OR

14. Describe the different wear mechanisms with the help of neat sketches. (14 marks)

Module 3

15. Explain the variation of friction behavior using the Stribeck curve and describe how the contact condition gradually changes from direct surface interaction to complete fluid film separation in industrial applications. (14 marks)

OR

16. Discuss lubricant selection criteria. Explain the different lubricant additives and their functions. (14 marks)

Module 4

17. Discuss various surface protection treatments. Explain the mechanisms by which these treatments improve wear resistance and reduce friction. (14 marks)

OR

18. Explain the concept of condition-based maintenance and lubrication scheduling. Explain how the monitoring and inspection techniques help in preventing tribological failures. (14 marks)

Module 5

19. Discuss the role of tribology in automotive systems. Explain how proper lubrication and maintenance influence component efficiency and service life. (14 marks)

OR

20. Describe emerging sustainable practices in tribology. Discuss their impact on environmental protection and long-term industrial performance. (14 marks)

KNOWLEDGE IS POWER

B24ME4P34	RENEWABLE ENERGY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The course introduces students to the concepts, technologies, and applications of renewable energy systems with emphasis on solar, wind, energy storage, hydrogen energy, and other emerging renewable technologies. The course also highlights environmental impacts, sustainability considerations, and life cycle aspects of renewable energy deployment. Students will be equipped to understand renewable energy potentials, system design fundamentals, and energy storage technologies required for sustainable power systems.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain energy scenarios, classification of energy sources, environmental impacts, CO_2 emissions, and renewable energy potential in India. (Cognitive Knowledge Level: Understand)
CO 2	Explain principles of solar radiation, solar collectors, photovoltaic systems and related applications. (Cognitive Knowledge Level: Understand)
CO 3	Apply aerodynamic principles to explain and differentiate various wind energy conversion system (WECS) configurations. (Cognitive Knowledge Level: Apply)
CO 4	Explain various energy storage technologies including mechanical, electrochemical, and thermal storage systems. (Cognitive Knowledge Level: Understand)
CO 5	Explain hydrogen energy systems and qualitatively analyze other renewable energy resources and life cycle aspects. (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										
CO 2	3	3			1	1	1				1
CO 3	3	3			1	1	1				1
CO 4	3	3			1	1	1				1
CO 5	3	3			1	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	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Fundamentals of Renewable Energy and Environmental Impact (6 hours)

Introduction to different types of non-conventional source of energy: Solar, Wind, Biomass, Tidal, and Geothermal Energy. CO_2 Emission - Features of Renewable energy – Renewable energy scenario in India -Environmental aspects of electric energy conversion: Impacts of renewable energy generation on environment Per Capita Energy Consumption - Carbon Footprints - Importance of renewable energy sources, Potentials – Achievements– Applications.

MODULE 2: Solar Energy Systems and Applications (7 hours)

Solar Energy: Sun and Earth-Basic Characteristics of solar radiation- Types of solar collectors-Flat plate collectors –Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector), Angle of sunrays on solar collector-Estimating Solar Radiation Empirically, Solar Photovoltaic system for power generation, Solar Cells-Types of solar cells, Solar Pond, Solar drier, Solar refrigeration and air-conditioning.

MODULE 3: Wind Energy Conversion Systems and Aerodynamics (8 hours)

Origin of Winds: Global and Local Winds- Derivation of Betz's limit- Power available in wind-Classification of wind turbine: Horizontal Axis wind turbine (with Examples) and Vertical axis wind turbine (with Examples)- Aerodynamic Efficiency-Tip Speed-Tip Speed Ratio-Solidity-Blade Count-Power curve of wind turbine - Configurations of wind energy conversion systems: Type A, Type B, Type C and Type D Configurations.

MODULE 4: Hydrogen Energy and Biomass Conversion Technologies (8 hours)

Hydrogen energy: Hydrogen production- (Steam Methane Reforming, Partial Oxidation Process, Gasification Process (Coal and Biomass), Water Electrolysis Process), Hydrogen Transportation, Hydrogen storage methods (Compressed Gas Storage, Liquid Hydrogen Storage, Metal Hydride Storage), Case studies. Government Policy for Hydrogen (India), Green Hydrogen, Hydrogen Valley. Biomass Energy- Biomass conversion technologies – Biomass Gasification- Process, Types of gasifiers.

MODULE 5: Energy Storage Technologies and Applications (7 hours)

Introduction of energy storage technology. Mechanical energy storage systems: Spring-Based Mechanical Energy Storage, Pumped Hydropower storage (PHS), and Compressed-Air Energy Storage (CAES). Electrochemical energy storage: Battery, Fuel Cell, and Capacitor. Comparison and application of state-of-arts including principle, function and deployments.
Thermal energy storage: Sensible heat storage (SHS), Latent Heat Storage (LHS) or Phase-Change Materials (PCMs), and Thermo-Chemical Energy Storage (TCES).

Text Books

1. S P Sukhatme, J K Nayak, *Solar Energy: Principles of Thermal Collection and Storage,* Mc Graw Hill.
2. Tiwari G N, Ghosal M K, *Fundamentals of renewable energy sources,* Alpha Science International Ltd.
3. Jefferson W Tester et.a., *Sustainable Energy Choosing among options*, PHI.

Reference Books

1. D.P. Kothari, *Renewable energy resources and emerging technologies*, Prentice Hall of India Pvt. Ltd.
2. Mehmet Kanoğlu Yunus A. Çengel John M. Cimbala, *Fundamentals and Applications of Renewable Energy,* Mc Graw Hill.
3. Roland Wengenmayr, Thomas Buhrke, '*Renewable Energy: Sustainable energy concepts for the future*, Wiley – VCH.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**6**
1.1	Introduction to different types of non-conventional source of energy: Solar, Wind, Biomass, Tidal, and Geothermal Energy. CO_2 Emission - Features of Renewable energy – Renewable energy scenario in India.	2
1.2	Environmental aspects of electric energy conversion: Impacts of renewable energy generation on environment.	2
1.3	Per Capita Energy Consumption - Carbon Footprints	1
1.4	Importance of renewable energy sources, Potentials – Achievements– Applications.	1
	Module 2	**7**
2.1	Solar Energy: Sun and Earth-Basic Characteristics of solar radiation	1
2.2	Types of solar collectors- Flat plate collectors –Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector).	2
2.3	Angle of sunrays on solar collector-Estimating Solar Radiation Empirically.	2
2.4	Solar Photovoltaic system for power generation, Solar Cells-Types of solar cells, Solar Pond, Solar drier, Solar refrigeration and air-conditioning.	2
	Module 3	**8**
3.1	Origin of Winds: Global and Local Winds- Derivation of Betz's limit- Power available in wind.	2
3.2	Classification of wind turbine: Horizontal Axis wind turbine (with Examples) and Vertical axis wind turbine (with Examples).	2
3.3	Aerodynamic Efficiency-Tip Speed-Tip Speed Ratio-Solidity-Blade Count-Power curve of wind turbine.	2
3.4	Configurations of wind energy conversion systems: Type A, Type B, Type C and Type D Configurations.	2
	Module 4	**8**
4.1	Hydrogen energy: Hydrogen production- (Steam Methane Reforming, Partial Oxidation Process, Gasification Process (Coal and Biomass), Water Electrolysis Process).	2
4.2	Hydrogen Transportation, Hydrogen storage methods (Compressed Gas Storage, Liquid Hydrogen Storage, Metal Hydride Storage).	2

4.3	Case studies. Government Policy for Hydrogen (India), Green Hydrogen, Hydrogen Valley.	2
4.4	Biomass Energy- Biomass conversion technologies –Biomass Gasification- Process, Types of gasifiers.	2
	Module 5	**7**
5.1	Introduction of energy storage technology. Mechanical energy storage systems: Spring-Based Mechanical Energy Storage, Pumped Hydropower storage (PHS), and Compressed-Air Energy Storage (CAES).	2
5.2	Electrochemical energy storage: Battery, Fuel Cell, and Capacitor. Comparison and application of state-of-arts including principle, function and deployments.	3
5.3	Thermal energy storage: Sensible heat storage (SHS), Latent Heat Storage (LHS) or Phase-Change Materials (PCMs), and Thermo-Chemical Energy Storage (TCES).	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. What are the different classifications of energy sources?
2. Explain the renewable energy scenario in India with respect to potential and achievements.
3. Define: (i) Per capita energy consumption (ii) CO_2 emission (iii) Renewable energy potential.

Course Outcome 2 (CO2):

1. Discuss different types of solar collectors.
2. Explain the working principle of a solar photovoltaic system.
3. Describe the effect of angle of incidence on solar collector performance.

Course Outcome 3 (CO3):

1. Derive Betz's limit and explain its significance.
2. Differentiate between Horizontal Axis Wind Turbine (HAWT) and Vertical Axis Wind Turbine (VAWT).
3. Explain the power curve of a wind turbine and define Tip Speed Ratio..

Course Outcome 4 (CO4):

1. Compare mechanical, electrochemical and thermal energy storage systems.
2. Explain the working of Pumped Hydro Storage (PHS) system.
3. Describe latent heat storage using Phase Change Materials (PCM).

Course Outcome 5 (CO5)

1. Explain different methods of hydrogen production.
2. Write a short note on Ocean Thermal Energy Conversion (OTEC).
3. What is Life Cycle Analysis (LCA)? Explain its importance in renewable energy systems.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4P34**

Course Name: **RENEWABLE ENERGY**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1	Discuss briefly the importance of renewable energy in reducing CO_2 emissions.	
2	Explain the following terms related to solar radiation: (i) Solar Constant (ii) Angle of Incidence (iii) Declination.	
3	List different types of solar collectors.	
4	What are the applications of solar photovoltaic systems?	
5	State Betz's limit and mention its significance.	
6	List the different configurations of Wind Energy Conversion Systems (WECS).	
7	Name the mechanical energy storage systems used for renewable energy applications.	
8	What are the advantages of thermal energy storage systems?	
9	List the different methods of hydrogen production.	
10	Mention various renewable energy resources other than solar and wind.	

PART B

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

Module 1

11	Explain the renewable energy scenario in India. Discuss classification of energy sources and environmental impacts of conventional energy systems.	(14 Marks)

OR

12 a. Explain per capita energy consumption and its importance. (4 Marks)

b. Discuss environmental aspects of electric energy conversion and CO_2 emission issues. (10 Marks)

Module 2

13 a. Draw and explain the construction and working of a flat plate solar collector. (10 Marks)

b. Briefly explain the applications of a solar PV system. (4 Marks)

OR

14 a. Explain different types of solar concentrators with neat sketches. (10 Marks)

b. Describe solar refrigeration and air-conditioning. (4 Marks)

Module 3

15 Derive the expression for power available in wind and explain Betz's limit. (14 marks)

OR

16 a. Classify wind turbines and explain HAWT and VAWT. (7 Marks)

b. Explain different WECS configurations (Type A, B, C and D). (7 Marks)

Module 4

17 Explain mechanical, electrochemical and thermal energy storage systems with suitable examples. (14 Marks)

OR

18 Explain the working principle and applications of: a. Pumped Hydro Storage (PHS), b. Latent Heat Storage using PCM. (14 Marks)

Module 5

19 Explain hydrogen production, transportation and storage methods in detail. (14 marks)

OR

20 a. Explain the principle and working of Ocean Thermal Energy Conversion (OTEC) system. (7 Marks)

b. Explain the construction and working of KVIC (floating type) bio gas plant. (7 Marks)

B24ME4P35	COMPUTATIONAL FLUID DYNAMICS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Computational Fluid Dynamics (CFD) is a powerful tool for analysing fluid flow and heat transfer in engineering systems. This course introduces the governing equations of fluid flow and their numerical solution using the finite volume method. Emphasis is placed on discretisation, solution strategies, convergence assessment, and grid independence. The course integrates theory with applications in internal and external flows and thermal management systems, enabling students to interpret CFD results critically and apply simulation tools in practical engineering design.

Pre-requisite

Nil.

Course Outcomes

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

CO 1	Explain the scope, CFD workflow, governing equations, and classification of PDEs in fluid flow problems. (Cognitive Knowledge Level: Understand)
CO 2	Apply finite difference and finite volume methods to discretise transport equations and the solution strategies. (Cognitive Knowledge Level: Apply)
CO 3	Understand the basics of Turbulence models and the selection of appropriate turbulence models based on fluid characteristics. Cognitive Knowledge Level: Understand)
CO 4	*Compute* pressure drop, friction factor, and drag coefficient for internal and external incompressible flows using CFD, and *determine* flow characteristics such as boundary-layer development and wake behavior. (Cognitive Knowledge Level: Apply)
CO 5	*Compute* temperature distribution and cooling effectiveness in conjugate heat transfer systems using CFD. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	3	3	2	2	1					1	
CO 2	3	2	2	1	2					1	
CO 3	3	3	2	1	2					1	
CO 4	3	3	2	2	2					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	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Introduction to CFD (7 hours)

Introduction to CFD – Scope and Applications: Role of CFD in engineering analysis, advantages and limitations, applications in various domains. CFD Solution Procedure: Pre-processing (problem definition, geometry, domain, mesh generation, boundary conditions), Solver (discretisation concept, algebraic equation formation, iterative solution, convergence), Post-processing (contours, vectors, streamlines, drag, lift).

Governing Equations: Continuity equation, Navier–Stokes equations, energy equation, general scalar transport equation, integral control volume concept, physical meaning of convection, diffusion and source terms.

Classification of PDEs: General form. Linear and non-linear PDEs, elliptic, parabolic and hyperbolic equations and their physical interpretation in fluid flow problems.

MODULE 2: Discretisation Techniques and Solution Strategy (7 hours)

Finite Difference Method based on Taylor series expansion. Finite Volume Method and control volume formulation. Discretisation of 2D convection–diffusion equation of the general scalar transport equation. Central Differencing Scheme (CDS) and Upwind Differencing Scheme. Peclet number and its significance. Discretised momentum equations and the pressure–velocity coupling issue in incompressible flows. SIMPLE algorithm (conceptual steps).

Solution of algebraic equation systems: Sparse matrix concepts, direct and iterative methods, TDMA. Under-relaxation for convergence control. Time discretisation (explicit vs implicit). CFL condition (concept). Convergence criteria and residual monitoring. Grid independence study, verification and validation. Types of meshes. Brief discussion on accuracy, stability and convergence of numerical schemes. Implementation of boundary conditions: Dirichlet, Neumann and wall (no-slip).

MODULE 3: Basics of Turbulence Modelling (7 hours)

Introduction to turbulence modelling: Reynolds Averaged Navier – Stokes equation (RANS) - Reynolds' stress component, closure problem, Boussinesq approximation and Eddy viscosity, Mixing length model, Two equation models: k-epsilon and k-omega models. RSM, LES and DNS. Comparison of turbulence models and its suitability.

MODULE 4: Incompressible Internal and External Flows (7 hours)

Internal flows: laminar and turbulent pipe flow, Reynolds number effects, and fully developed flow. CFD modelling of pipe flow and 90-degree pipe bend. Pressure drop, friction factor and secondary flow analysis.

External flows: boundary-layer development, separation, and wake formation. CFD analysis of flow past a circular cylinder at different Reynolds numbers. Steady and unsteady simulation concepts. Drag coefficient estimation, wake structure analysis and turbulence model comparison. Validation with benchmark data (concept).

MODULE 5: CFD Analysis of Conjugate Heat Transfer and Thermal Management (8 hours)

Fluid–solid interaction in thermal systems. Interface boundary conditions: temperature continuity and heat flux continuity. Coupling of conduction in solids and convection in fluids. Specification of thermal boundary conditions: Fixed wall temperature, Specified heat flux,

Adiabatic boundary.

Thermal Performance Evaluation – Forced Convection Over Extended Surfaces. Heat transfer coefficient and Nusselt number (concept). Thermal resistance concept for multi-layer systems. Validation of CFD results with the theoretical thermal resistance model. Pressure drop–cooling trade-off in finned heat sinks. Influence of fin spacing and geometric parameters.

Application study of heat sink for high-performance processors: temperature distribution, hot spot identification, airflow management and performance comparison under varying operating conditions.

Reference Books

1. H.K. Versteeg & W. Malalasekera, *An Introduction to Computational Fluid Dynamics* – The Finite Volume Method, Pearson.
2. Ferziger, J.H., Perić, M., and Street, R.L., *Computational Methods for Fluid Dynamics,* Springer.
3. Anderson, J.D., *Computational Fluid Dynamics: The Basics with Applications*, McGraw-Hill.
4. Patankar, S.V., *Numerical Heat Transfer and Fluid Flow*, Hemisphere Publishing.
5. Tu, Jiyuan, Yeoh, Guan Heng & Liu, Chaoqun, *Computational Fluid Dynamics: A Practical Approach*, Butterworth-Heinemann.

COURSE CONTENT AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Introduction to CFD – Scope and Applications: Role of CFD in engineering analysis, advantages and limitations, applications in various domains. CFD Solution Procedure: Pre-processing (problem definition, geometry, domain, mesh generation, boundary conditions), Solver (discretisation concept, algebraic equation formation, iterative solution, convergence), post-processing (contours, vectors, streamlines, drag, lift). (Show with an example)	1
1.2	Governing Equations: Continuity equation, Navier–Stokes equations. Differential form. Vector representation.	2
1.3	Governing equation-Energy equation, general scalar transport equation, integral form of general scalar transport equation and explanation of the convection, diffusion and source term. (concept)	2
1.4	Classification of PDEs: General form. Linear and non-linear PDEs, elliptic, parabolic and hyperbolic equations and their physical interpretation in fluid flow problems.	2
	Module 2	**7**
2.1	Discretisation: Finite Difference Method - Taylor series expansion, First and second order derivatives. Forward, backward and central difference. Concept of truncation error and order of accuracy.	1

	Approximations.	
2.3	Discretisation of 2D Convection–Diffusion Equation. General scalar transport equation (GSTE). Control volume formulation. Discretisation Schemes: Central Difference Scheme (CDS), Upwind Difference Scheme (UDS). Peclet number- Identifying convection-dominated and diffusion-dominated flows.	2
2.4	Discretised momentum equations and the pressure–velocity coupling issue in incompressible flows. Concept of the SIMPLE algorithm. Solution of algebraic systems of equations: Sparse matrix concepts, direct and iterative methods, TDMA. Under-relaxation for convergence control. Time discretisation (explicit vs implicit). CFL condition (concept).	2
2.5	Accuracy, Stability and Convergence of Numerical Schemes. (qualitative discussion). Implementation of Boundary Conditions in CFD. Importance of boundary conditions in closing the governing equations. Dirichlet boundary condition (specified variable value). Neumann boundary condition (specified gradient). Wall boundary condition: no-slip condition in viscous flows. Types of Meshes- Structured and unstructured. 2D and 3D, Hybrid mesh and boundary layer mesh (inflation).	1
2.6	Convergence Monitoring, Residual definition, Residual monitoring, Convergence criteria. Grid Independence Study-Importance of mesh refinement. Procedure for grid independence test.	1
	Module 3	**7**
3.1	Introduction to Turbulence Modelling: Characteristics of turbulent flows. Need for turbulence modelling in CFD. Reynolds averaging concept and the derivation of RANS equations.	2
3.2	Reynolds' stress component, closure problem, Boussinesq approximation and Eddy viscosity, Mixing length model, Two equation models k-epsilon and k-omega models.	2
3.3	RSM, LES and DNS. Comparison of turbulence models in terms of computational cost and accuracy. Selection of appropriate turbulence models depending on the characteristics of the fluid flow problem. Case study discussion.	3
	Module 4	**7**
4.1	Internal flows: laminar and turbulent pipe flow, Reynolds number effects, and fully developed flow. CFD modelling of pipe flow and 90-degree pipe bend. concept of y+. Pressure drop, friction factor and secondary flow analysis.	2
4.2	External flows: boundary-layer development, separation, and wake formation. CFD analysis of flow past a circular cylinder at different Reynolds numbers.	3
4.3	Steady and unsteady simulation concepts. Drag coefficient estimation, wake structure analysis and turbulence model comparison. Validation with benchmark data.	2
	Module 5	**8**
5.1	Fluid–solid interaction in thermal systems. Coupling of conduction in solids and convection in fluids. Concept of conjugate heat	1

	transfer in CFD.	
5.2	Interface boundary conditions: temperature continuity and heat flux continuity. Coupling of conduction in solids and convection in fluids. Specification of thermal boundary conditions: Fixed wall temperature, Specified heat flux, Adiabatic boundary.	1
5.3	Forced Convection Over Extended Surfaces: Concept of forced convection over finned surfaces. Heat transfer coefficient and Nusselt number (concept)—role of airflow in enhancing cooling performance.	1
5.4	Thermal Performance Evaluation: Thermal resistance concept for multi-layer systems. Validation of CFD results with theoretical thermal resistance models. Pressure drop–cooling trade-off in finned heat sinks.	1
5.5	Design Parameters in Heat Sink Performance: Influence of fin spacing and geometric parameters. Effect of airflow and geometry on cooling efficiency—interpretation of CFD results for thermal management applications.	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the main steps involved in the CFD solution procedure.
2. Write the general scalar transport equation and briefly explain the convection, diffusion and source terms.
3. Show the general form of a second-order PDE and the criteria used for classification.

Course Outcome 2 (CO2):

1. Write the forward, backward and central difference approximations for the first derivative.
2. What is the finite volume method? Briefly explain the concept of a control volume.
3. Explain accuracy, stability and convergence of a numerical scheme

Course Outcome 3 (CO3):

1. What is the RANS concept and the major turbulence closure models?
2. Define Reynolds' stress component
3. Explain the suitability of turbulence models depending on the fluid nature.

Course Outcome 4 (CO4):

1. What is a fully developed flow in pipe flow?
2. Define drag coefficient and mention the factors affecting it in external flows.
3. What is flow separation? Why does it occur in external flows?

Course Outcome 5 (CO5):

1. What is conjugate heat transfer?
2. What are temperature continuity and heat flux continuity at a fluid–solid interface?
3. What is the role of fin spacing in heat sink performance?

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4P35**

Course Name: **COMPUTATIONAL FLUID DYNAMICS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1		Explain the main steps involved in the CFD solution procedure.
2		Write the general scalar transport equation and briefly explain the convection, diffusion and source terms.
3		Define truncation error. How does it relate to the order of accuracy of a numerical scheme?
4		Define the Peclet number and explain how it helps identify convection-dominated and diffusion-dominated flows.
5		Explain the concept of the Eddy viscosity model.
6		How is an Eddy viscosity model different from the Reynolds Stress Model?
7		Explain the significance of the Reynolds number in pipe flow.
8		Define drag coefficient and mention the factors affecting it in external flows.
9		Explain conjugate heat transfer?
10		Discuss the role of fin spacing in heat sink performance

PART B

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

Module 1

11		Explain the Navier–Stokes equations in differential form and discuss their physical significance in fluid flow problems.	(14 marks)

OR

12	a.	Show the general form of a second-order PDE and the criteria used for classification.	(7 marks)
	b.	Explain the characteristics and typical fluid flow problems associated with elliptic, parabolic and hyperbolic equations.	(7 marks)

Module II

13 a. Derive the forward, backward and central difference approximations for the first derivative using Taylor series expansion. (7 marks)

b. Describe Dirichlet, Neumann and wall (no-slip) boundary conditions with suitable examples from fluid flow or heat transfer problems. (7 marks)

OR

14 Consider a 1D steady-state flow of an incompressible fluid through a pipe. The velocity field is governed by the discretised momentum equation:

$$a_P u_P = a_E u_E + a_W u_W + b$$

where: $a_P = 3,\ a_W = 1, a_E = 1, b = 2$

The domain consists of 3 grid points P_1, P_2 and P_3. The boundary condition is $u_1 = 0, u_3 = 4$. Use the SIMPLE algorithm to solve for the velocity values. (14 marks)

Module III

15 Discuss briefly on (i) Reynolds Stress component (ii) Eddy viscosity (iii) k-ε model (iv) k-**w** model (v) Reynolds Stress Model (vi) LES (vii) DNS. (14 marks)

OR

16 Describe the turbulence closure problem arising from the Reynolds-averaged Navier–Stokes (RANS) equations and explain the eddy viscosity concept used to model turbulent stresses. (14 marks)

Module IV

17 a. A CFD engineer is asked to analyse the flow through a pipe system containing a straight pipe followed by a 90° bend. Explain how Reynolds number influences the flow regime in pipe flow and discuss the conditions required for fully developed flow in a straight pipe. (6 marks)

b. Analyse the flow behaviour in a 90° pipe bend and explain how pressure drop, friction factor and secondary flows can be evaluated using CFD. Briefly discuss the importance of y^+ in resolving near-wall flow behaviour. (8 marks)

OR

18 a. Describe the boundary-layer development, flow separation and wake formation around a circular cylinder and explain how it changes with Reynolds number. (7 marks)

b. Explain how CFD simulations can be used to estimate the drag coefficient and analyse the wake structure. Briefly discuss the role of turbulence models and validation with benchmark data. (7 marks)

Module V

19 a. Describe the interface boundary conditions at a fluid–solid interface, explaining the concepts of temperature continuity and heat flux continuity. (7 marks)

b. Explain the thermal boundary conditions used in CFD, namely fixed wall temperature, specified heat flux and adiabatic wall, with suitable examples from heat transfer applications. (7 marks)

OR

20 a. Evaluate the thermal performance of finned heat sinks using concepts of thermal resistance and pressure drop–cooling trade-off. (7 marks)

b. Analyse the CFD study of a heat sink for processor cooling, focusing on temperature distribution, hotspot identification & effect of airflow conditions. (7 marks)

B24ME4P36	INDUSTRIAL HYDRAULICS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Fluid power systems play a vital role in modern engineering applications, enabling efficient transmission and control of power using liquids and gases. These systems are widely used in manufacturing, automation, transportation, and heavy machinery due to their flexibility, precision, and high power-to-weight ratio. This course provides a comprehensive understanding of hydraulic and pneumatic systems, covering their components, working principles, control strategies, and industrial applications. Emphasis is placed on system design, performance characteristics, circuit analysis, and practical implementation to equip students with the knowledge required for real-world engineering problems.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the basic principles, components, and properties of fluids used in hydraulic and pneumatic systems. (Cognitive Knowledge Level: Understand)
CO 2	Understand the construction and working principles of hydraulic pumps, accumulators, and fluid handling components. (Cognitive Knowledge Level: Understand)
CO 3	Understand the operation of hydraulic actuators, motors, and different types of control valves used in fluid power systems. (Cognitive Knowledge Level: Understand)
CO 4	Apply the principles of hydraulic circuits to analyze and explain the working of various industrial hydraulic systems. (Cognitive Knowledge Level: Apply)
CO 5	Apply the basic principles of pneumatic systems to understand compressed air generation, air preparation, and pneumatic actuators and valves used in industrial applications. (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	1						1		
CO 2	3	2	1	1					1		
CO 3	3	3	1	1					1		
CO 4	3	3	1	1					1		
CO 5	3	2	1	2					1		

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Fundamentals of Fluid Power Systems and Components (6 hours)

Classification of fluid power systems- Basic components, Symbols & circuits of a hydraulic and pneumatic system, Properties of fluids.

Hydraulic fluids and fluid handling components: - Fluids for hydraulic systems- Hydraulic fluid reservoirs- Hydraulic seals- Filters and Strainers.

MODULE 2: Hydraulic Pumps and Energy Storage Devices (7 hours)

Classification and pumping theory- Principle of working and constructional details of vane pump, gear pumps, piston pumps, radial and axial plunger pumps- Pump performance character tics and efficiencies of vane and gear pump. Hydraulic pressure intensifiers, Power storage devices –Accumulators.

MODULE 3: Hydraulic actuators & Control Valves (7 hours)

Linear hydraulic actuators-Types, Rotary actuator Classification, construction and working of gear, vane, axial and radial piston motors. Hydraulic control valves: -Classification of control valves- Directional control valves-Pressure control valves- Flow control valves- Servo valves, Hydraulic conductors.

MODULE 4: Hydraulic Circuits and System Design (8 hours)

Control of single and double -acting hydraulic cylinder, Regenerative circuit- Pump-unloading circuit, Double-pump hydraulic system, Pressure intensifier circuit, Counter balance valve application, Hydraulic cylinder sequencing circuits, Automatic cylinder reciprocating system, Locked cylinder using pilot check valves, Cylinder synchronizing circuits- Speed control of a hydraulic cylinder, Bleed-off flow control circuit-Fail-safe circuits- Hydraulic motor breaking system, Hydraulic circuit examples with accumulator.

MODULE 5: Pneumatic Systems and Industrial Applications (8 hours)

Pneumatic systems: basic principle of compressed air, comparison between hydraulic and pneumatic systems, advantages and limitations of pneumatics, and typical industrial applications. Properties of compressed air including basic gas laws, Boyle's law and Charles law. Air generation and preparation: basic types of air compressors, air receivers, air distribution systems, and air treatment components such as filters, regulators, and lubricators (FRL unit). Pneumatic actuators: working principle of single acting and double acting cylinders, introduction to rotary actuators with applications. Pneumatic valves including direction control valves (2/2, 3/2, 4/2 and 5/2 valves), flow control valves, pressure control valves, valve actuation: manual, mechanical, pneumatic, and solenoid actuation.

Text Books

1. Jagadeesh T, *Hydraulics and Pnematics*, Dreamtech Press.
2. Iango sivaraman. *Introduction to hydraulics and pneumatics*, PHI

Reference Books

1. Andrew Parr, *Hydraulics and Pneumatics: A Technician's and Engineer's Guide*, Elsevier Publication.
2. M. Winston, *Essential Hydraulics-Fluid Power Basic*, Createspace Independent Pub.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**6**
1.1	Classification of fluid power systems- Basic components, Symbols & circuits of a hydraulic and pneumatic system.	2
1.2	Properties of fluids.	1
1.3	Hydraulic fluids and fluid handling components: - Fluids for hydraulic systems	1
1.4	Hydraulic fluid reservoirs- Hydraulic seals- Filters and Strainers.	2
	Module 2	**7**
2.1	Classification and pumping theory- Principle of working and constructional details of vane pump, gear pumps, piston pumps, radial and axial plunger pumps	2
2.2	Pump performance character tics and efficiencies of vane and gear pump	2
2.3	Hydraulic pressure intensifiers, Power storage devices – Accumulators.	3
	Module 3	**7**
3.1	Hydraulic actuators & Control Valves:- Linear hydraulic actuators- Types, Rotary actuator Classification	2
3.2	construction and working of gear, vane, axial and radial piston motors.	2
3.3	Hydraulic control valves: -Classification of control valves- Directional control valves	2
3.4	Pressure control valves- Flow control valves- Servo valves, Hydraulic conductors	1
	Module 4	**8**
4.1	Hydraulic circuits: - Control of single and double -acting hydraulic cylinder, Regenerative circuit- Pump-unloading circuit.	2
4.2	Double-pump hydraulic system, Pressure intensifier circuit, Counter balance valve application, Hydraulic cylinder sequencing circuits,	2
4.3	Automatic cylinder reciprocating system, Locked cylinder using pilot check valves, Cylinder synchronizing circuits-	2
4.4	Speed control of a hydraulic cylinder, Bleed-off flow control circuit-Fail-safe circuits- Hydraulic motor braking system, Hydraulic circuit examples with accumulator.	2
	Module 5	**8**
5.1	Pneumatic systems: basic principle of compressed air, comparison between hydraulic and pneumatic systems, advantages and limitations of pneumatics, and typical industrial applications.	2
5.2	Properties of compressed air including basic gas laws, Boyle's law and Charles law	2
5.3	Air generation and preparation: basic types of air compressors, air receivers, air distribution systems, and air treatment components	2

	such as filters, regulators, and lubricators (FRL unit).	
5.4	Pneumatic actuators: working principle of single acting and double acting cylinders, introduction to rotary actuators with applications. Pneumatic valves including direction control valves (2/2, 3/2, 4/2 and 5/2 valves), flow control valves, pressure control valves, valve actuation: manual, mechanical, pneumatic, and solenoid actuation	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the classification of fluid power systems and describe the basic components of a hydraulic system with suitable symbols.
2. Discuss the important properties of hydraulic fluids required for efficient operation of hydraulic systems.
3. Explain the construction and functions of hydraulic reservoirs, filters, and strainers in fluid power systems.

Course Outcome 2 (CO2):

1. Explain the construction and working principle of gear pumps with neat sketches.
2. Describe the working of vane pumps and discuss their advantages and limitations.
3. Explain the construction and working of axial piston pumps and radial piston pumps.

Course Outcome 3 (CO3):

1. Explain the construction and working of hydraulic cylinders and discuss their different types.
2. Classify hydraulic control valves and explain the working of directional control valves with suitable symbols.
3. Explain the construction and working of hydraulic motors used in rotary actuators.

Course Outcome 4 (CO4):

1. Explain the working of regenerative hydraulic circuits with neat sketches.
2. Describe the working of cylinder sequencing circuits and automatic cylinder reciprocating systems.
3. Explain the working of cylinder synchronizing circuits and bleed-off flow control circuits.

Course Outcome 5 (CO5)

1. Explain the basic principle of compressed air and compare pneumatic systems with hydraulic systems.
2. Describe the working of air compressors, air receivers, and air distribution systems used in pneumatic systems.
3. Explain the construction and working of pneumatic cylinders and directional control valves used in pneumatic systems.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4P36**

Course Name: **INDUSTRIAL HYDRAULICS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Explain the classification of fluid power systems.
2 Describe the functions of hydraulic reservoirs and filters.
3 Describe the working principle of a gear pump.
4 State the function of a hydraulic accumulator.
5 Explain the working of a hydraulic cylinder.
6 What is the function of a pressure control valve.
7 Describe the working of a regenerative hydraulic circuit.
8 State the purpose of a pump unloading circuit
9 Explain Boyle's law in compressed air systems.
10 Discuss the function of an FRL unit in pneumatic systems.

PART B

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

Module 1

11 a. Classify fluid power systems and compare hydraulic and pneumatic systems based on working principle, components, and applications. (7 Marks)

b. Discuss the properties required for an ideal hydraulic fluid and explain the functions of hydraulic reservoirs, seals, filters, and strainers in a hydraulic system. (7 Marks)

OR

12 a. Explain the basic components of a hydraulic and pneumatic system with suitable circuit symbols. (7 Marks)

b. Describe the construction and working of a hydraulic fluid reservoir and explain different types of hydraulic seals used in fluid power systems. (7 Marks)

Module 2

13 a. Explain the construction and working principle of vane pumps and gear pumps with neat sketches. (7 Marks)

b. A gear pump delivers 20 L/min of oil at a pressure of 5 MPa. If the mechanical efficiency is 85% and volumetric efficiency is 90%, determine:
i) Theoretical discharge
ii) Input power required to drive the pump. (7 Marks)

OR

14 a. Explain the construction and working of radial and axial piston pumps and compare their performance characteristics. (7 Marks)

b. A hydraulic accumulator stores 8 litres of oil at a pressure of 10 MPa. If the oil is released at 4 MPa, determine the energy released by the accumulator. (7 Marks)

Module 3

15 a. Describe the construction and operational principles of various hydraulic actuators, providing a detailed comparison between linear and rotary types. (7 marks)

b. Explain the construction and working of gear motors, vane motors, and axial piston motors used in hydraulic systems. (7 marks)

OR

16 a. Classify hydraulic control valves and explain the working of directional control valves with suitable symbols. (7 Marks)

b. Explain the working of pressure control valves and flow control valves and discuss their importance in hydraulic circuit operation. (7 Marks)

Module 4

17 a. Compare the working mechanisms of a regenerative hydraulic circuit with a pump-unloading circuit, explaining how each contributes to system efficiency and speed. (7 Marks)

b. Explain the working of cylinder sequencing circuits and automatic cylinder reciprocating systems with suitable diagrams. (7 Marks)

OR

18 a. Explain the principle and working of cylinder synchronizing circuits and bleed-off flow control circuits (7 Marks)

b. Discuss fail-safe circuits and hydraulic motor braking systems used in industrial hydraulic circuits (7 Marks)

Module 5

19 a. Explain the basic principle of compressed air and compare pneumatic systems with hydraulic systems in terms of advantages, limitations, and applications. (7 marks)

b. Air at a pressure of 100 kPa occupies a volume of 0.5 m^3. If the pressure increases to 400 kPa, determine the final volume assuming Boyle's law is applicable.

(7 marks)

OR

20 a. Explain the construction and working of air compressors, air receivers, and air distribution systems used in pneumatic systems. (7 Marks)

b. A pneumatic cylinder has a piston diameter of 80 mm and operates at an air pressure of 6 bar. Calculate the force developed during the extension stroke. (7 Marks)

B24ME4P37	ADVANCED METAL JOINING TECHNIQUES	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The manufacturing landscape is undergoing a rapid transformation driven by the demand for high-precision, high-performance components in industries such as aerospace, nuclear energy, automotive, and electronics. Traditional welding methods often fall short when dealing with exotic materials, extreme thickness variations, or the requirement for minimal heat-affected zones. This course, Advanced Metal Joining Techniques, is designed to bridge the gap between conventional fabrication and high-technology joining requirements by providing a comprehensive understanding of non-conventional and high-energy-density joining techniques. Students will explore the fundamental physics and governing principles behind advanced processes such as Radiant Energy Welding (Electron Beam and Laser Beam), Solid-State Joining (Diffusion, Friction, and Friction Stir Welding), and specialized methods like Ultrasonic, Plasma Arc, and Underwater Welding.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the physics, equipment, and applications of Electron Beam Welding (EBW) and Laser Beam Welding (LBW). (Cognitive Knowledge Level: Understand)
CO 2	Utilize the principles and process parameters of diffusion welding and adhesive bonding to solve practical joining problems. (Cognitive Knowledge Level: Apply)
CO 3	Describe he principles, equipment, process characteristics, and applications of explosive welding and friction welding. (Cognitive Knowledge Level: Understand)
CO 4	Explain the principles, equipment, operating procedures, and applications of ultrasonic welding and brazing processes. (Cognitive Knowledge Level: Understand)
CO 5	Select appropriate specialized welding processes such as plasma arc, MIAB, and underwater welding for specific industrial requirements. (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	1	–	2	1	–	–	–	–	1
CO 2	3	2	2	1	2	1	–	–	–	–	1
CO 3	3	2	1	–	1	2	–	–	–	–	1
CO 4	3	2	1	–	1	1	–	–	–	–	1
CO 5	3	2	3	1	3	2	–	–	1	1	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Radiant Energy Welding (7 Hours)

Radiant energy welding: Electron Beam Welding (EBW) principle and theory-equipment and systems-process characteristics and variables-weld joint design-applications-EBW process variants. Laser Beam Welding (LBW)-principle and theory-operation-types of lasers-process variables and characteristics-applications.

Module 2: Diffusion Welding and Adhesive Bonding (7 Hours)

Diffusion welding-principle and theory-methods-welding parameters-advantages and limitations-applications. Cold pressure welding-process, equipment, and set-up-applications. Adhesive Bonding-principle and theory-types of adhesives-joint design-bonding methods-applications.

Module 3: Explosive and Friction Welding (8 Hours)

Explosive welding-principle and theory-process variables-equipment-joint design-advantages and limitations-applications. Friction welding-principle and theory-process variables-advantages and limitations-applications. Friction stir welding-metal flow phenomena-tools-process variables-applications.

Module 4: Ultrasonic Welding and Brazing (7 Hours)

Ultrasonic welding-principle and theory-process variables and equipment-types of ultrasonic welds-advantages and limitations-applications. Brazing-principle-brazing processes-torch brazing-furnace brazing-vacuum brazing-induction brazing-advantages and limitations-applications.

Module 5: Plasma Arc and Special Joining (7 Hours)

Plasma arc welding-principle and theory-transferred arc and non-transferred arc techniques-equipment-advantages and limitations-applications. Magnetically impelled arc butt (MIAB) welding-principle of operation-applications. Underwater welding-wet and dry underwater welding-set-up for underwater welding systems.

Textbooks

1. Parmar R.S., *Welding Processes and Technology*, Khanna Publishers, Delhi.

References

1. *ASM Metals Handbook "Welding and Brazing*", Vol.6, ASM, Ohio.
2. Parmar R.S., "*Welding Engineering and Technology*", Khanna Publishers, Delhi.
3. Schwartz M.M., "*Metal Joining Manual*", McGraw-Hill Inc.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Principle of EBW, theory, and equipment systems.	1
1.2	Types of EBW welding guns and vacuum systems.	1
1.3	Process variables: beam current and welding speed effects.	1
1.4	EBW variants: medium vacuum and non-vacuum.	1
1.5	Weld joint design and preparation for EBW.	1
1.6	Principle of LBW, mechanism, and laser types.	1
1.7	LBW process variables and industrial applications.	1
	Module 2	**7**
2.1	Diffusion welding: principle, theory, and parameters.	1
2.2	Methods: Gas-pressure, Vacuum fusion, and Eutectic bonding.	1
2.3	Weldable materials and applications.	1
2.4	Cold pressure welding: set-up and applications.	1
2.5	Adhesive bonding: theory and classification.	1
2.6	Joint design for adhesives and bonding methods.	1
2.7	Industrial applications of adhesive bonding.	1
	Module 3	**8**
3.1	Explosive welding: principle and variables.	1
3.2	Set-up, joint design, and limitations.	1
3.3	Friction welding: principle and theory.	2
3.4	Speed effects on weld duration.	1
3.5	Friction Stir Welding (FSW): flow phenomena and tools.	2
3.6	Advantages and limitations of friction processes.	1
	Module 4	**7**
4.1	Ultrasonic welding: principle and equipment.	1
4.2	Process variables and weld types (spot/seam).	1
4.3	Advantages and industrial applications.	1
4.4	Brazing: principle and filler metal requirements.	1
4.5	Torch, Furnace, and Vacuum brazing.	2
4.6	Induction brazing: applications and limitations.	1
	Module 5	**7**
5.1	PAW: Transferred vs. Non-transferred arc.	1
5.2	PAW system components and "Keyholing."	1
5.3	PAW applications and limitations.	1
5.4	MIAB welding: principle and operation.	2
5.5	Underwater welding: wet and dry techniques.	2
	Total	**36 Hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Illustrate a typical EBW gun and explain its components.
2. Identify the process variables of Laser Beam Welding that affect weld quality.

Course Outcome 2 (CO2):

1. Describe the various stages involved in the diffusion welding process.
2. Classify adhesives used in industrial bonding and explain their characteristics.

Course Outcome 3 (CO3):

1. Compare the mechanism of metal joining in explosive welding with friction welding.
2. Explain the metal flow phenomena in Friction Stir Welding.

Course Outcome 4 (CO4):

1. Describe the principle of operation and variables of ultrasonic welding.
2. Compare torch brazing, furnace brazing, and vacuum brazing.

Course Outcome 5 (CO5)

1. Differentiate between transferred and non-transferred plasma arc processes.
2. Select the best welding process for underwater repair and justify your selection based on environment.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: B24ME4P37

***Course Name:* ADVANCED METAL JOINING TECHNIQUES**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Draw typical joint designs for EBW.
2. Define "f-number" for a laser beam.
3. What is vacuum fusion bonding?
4. Write a note on crack extension tests for adhesive bonds.
5. Define impact velocity in explosive welding.
6. Sketch a simple friction welding setup.
7. State the principle of ultrasonic welding.
8. List essential properties of brazing filler metals.
9. What is "keyholing" in PAW?
10. State the advantages of MIAB welding.

PART B

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

Module 1

11. a) With the help of a neat sketch, explain the working of an Electron Beam Welding (EBW) system. Discuss the role of the vacuum system and the difference between high-vacuum and non-vacuum EBW. (10 marks)

    (b) List any four industrial applications where EBW is preferred over conventional welding. (4 marks)

OR

12. a) Explain the principle of Laser Beam Welding (LBW). Discuss the various types of laser systems used in industrial welding applications. (7 marks)

(b) Analyze how process variables like laser power, beam diameter, and welding speed influence the depth of penetration. (7 marks)

Module 2

13. (a) Explain the fundamental theory of Diffusion Welding. Describe the three stages of the diffusion bonding process in detail. (10 marks)

    (b) What are the major parameters that govern a successful diffusion weld? (4 marks)

OR

14. a) Classify industrial adhesives based on their chemical composition and functional properties. (7 marks)

    (b) Discuss the various joint designs used in adhesive bonding and explain why surface preparation is critical for joint strength. (7 marks)

Module 3

15. (a) Describe the experimental set-up and the various stages of the Explosive Welding process with suitable sketches. (9 marks)

    (b) Explain the significance of "stand-off distance" and "collision velocity" in determining weld quality. (5 marks)

OR

16. (a) Explain the principle of Friction Stir Welding (FSW). Describe the metal flow phenomena and the thermal cycle involved during the process. (9 marks)

    (b) Sketch a typical FSW tool and explain the functions of the 'shoulder' and the 'pin' (probe). (5 marks)

Module 4

17. (a) Explain the principle and theory of Ultrasonic Welding. Describe the major components of the equipment including the transducer and sonotrode. (10 marks)

    (b) Distinguish between ultrasonic spot welding and ultrasonic seam welding. (4 marks)

OR

18. (a) Define Brazing. Explain the principle of capillary action and the essential properties required for a brazing filler metal. (6 marks)

    (b) Compare Torch Brazing and Vacuum Brazing. Under what industrial conditions would you recommend Vacuum Brazing? (8 marks)

Module 5

19. (a) Describe the system components of Plasma Arc Welding (PAW). Differentiate between the Transferred Arc and Non-Transferred Arc techniques. (10 marks)

    (b) Explain the "Keyholing" phenomenon in Plasma Arc Welding and its advantages for thick plate joining. (4 marks)

OR

20. (a) Discuss the general arrangement and safety requirements for Wet and Dry Underwater Welding systems. (8 marks)

    (b) Explain the principle of operation and the sequential steps involved in Magnetically Impelled Arc Butt (MIAB) welding. (6 marks)

B24ME4P38	ADVANCED MANUFACTURING TECHNIQUES	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The course Advanced Manufacturing Techniques introduces the principles, working mechanisms, capabilities, and applications of modern machining and fabrication processes such as electric discharge machining, electrochemical machining, laser beam machining, ultrasonic machining, abrasive jet machining, water jet machining, and additive manufacturing technologies. Emphasis is placed on understanding process parameters, material removal mechanisms, equipment configuration, advantages, limitations, and industrial applications.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the principles, classification, and working of advanced manufacturing processes and their significance over conventional methods. (Cognitive Knowledge Level: Understand)
CO 2	Discuss the working principles and process parameters of non-traditional machining processes and apply them to suitable industrial applications. (Cognitive Knowledge Level: Understand)
CO 3	Illustrate additive manufacturing technologies and implement rapid prototyping techniques in product development. (Cognitive Knowledge Level: Understand)
CO 4	Summarize the fundamentals of micro and nano manufacturing techniques and their engineering applications. (Cognitive Knowledge Level: Understand)
CO 5	Interpret automation and digital manufacturing concepts and utilize them in the context of Industry 4.0. (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	1						1		
CO 2	3	2	1	1					1		
CO 3	3	2	3	2	1				1		1
CO 4	3	2	2						1		
CO 5	3	2	2	2	2				1		1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	40	30
Understand	60	60	50
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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Fundamentals of Advanced Manufacturing Processes (7 hours)

Need for advanced manufacturing processes – Limitations of conventional manufacturing – Classification of advanced manufacturing techniques – Material removal processes vs material addition processes – Process selection criteria.
Overview of modern manufacturing technologies – Precision engineering – Hybrid manufacturing processes – Surface integrity in advanced machining – Applications in aerospace, biomedical and electronics industries.

MODULE 2: Mechanical Energy-Based Non-Traditional Machining Processes (7 hours)

Ultrasonic Machining (USM) – Principle, equipment, material removal mechanism, process parameters and applications.
Abrasive Jet Machining (AJM) – Working principle, nozzle design, abrasive materials, process parameters and applications.
Water Jet Machining (WJM) and Abrasive Water Jet Machining (AWJM) – System components, cutting mechanism, advantages, limitations and industrial applications.

MODULE 3: Thermal and Electrochemical Advanced Machining Processes (7 hours)

Electrical Discharge Machining (EDM) – Principle, equipment, spark generation, dielectric fluid, tool wear and applications.
Wire EDM – Construction, working principle and applications.
Electrochemical Machining (ECM) – Principle, tool design, electrolyte circulation, process parameters and applications.
Laser Beam Machining (LBM) – Principle, types of lasers, material removal mechanism and applications.
Electron Beam Machining (EBM) – Principle, equipment and industrial uses.

MODULE 4: Additive Manufacturing and Rapid Prototyping Technologies (7 hours)

Introduction to additive manufacturing – Advantages and limitations – Comparison with conventional manufacturing.
Rapid prototyping techniques - Stereo lithography - Selective Laser Sintering (SLS) - Fused Deposition Modeling (FDM) - Binder Jetting and Powder Bed Fusion, Laminated Object Manufacturing (LOM), Directed Energy Deposition (DED).
Process workflow in additive manufacturing – CAD model preparation – STL format – Slicing – Post processing – Applications in product development, medical implants and aerospace.

MODULE 5: Micro/Nano and Smart Manufacturing Systems (8 hours)

Micro-machining – Micro-EDM, Micro-ECM – Applications in MEMS.
Nano manufacturing – Basic concepts and techniques.
Hybrid manufacturing processes – Laser assisted machining – Ultrasonic assisted machining.
Smart manufacturing – Cyber physical systems – Digital manufacturing – Role of AI, IoT and automation in modern manufacturing.

Text Books

1. V. K. Jain, *Advanced Machining Processes*, Allied Publishers Pvt. Ltd., New Delhi.
2. P. C. Pandey and H. S. Shan, *Modern Machining Processes,* Tata McGraw-Hill

Publishing Company Ltd., New Delhi.

3. A. Ghosh & A. K. Mallik, *Manufacturing Science (2nd ed.)*. Affiliated East-West Press.

Reference Books

1. Benedict F. Boppana, *Nontraditional Manufacturing Processes*, CRC Press, Taylor & Francis Group.
2. Ian Gibson, David Rosen, and Brent Stucker, *Additive Manufacturing Technologies,* Springer, New York.
3. Mikell P. Groover, *Fundamentals of Modern Manufacturing*, John Wiley & Sons, Inc.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Need for advanced manufacturing processes – Limitations of conventional manufacturing – Classification of advanced manufacturing techniques	2
1.2	Material removal processes vs material addition processes – Process selection criteria.	2
1.3	Overview of modern manufacturing technologies – Precision engineering – Hybrid manufacturing processes	2
1.4	Surface integrity in advanced machining – Applications in aerospace, biomedical and electronics industries	1
	Module 2	**7**
2.1	Ultrasonic Machining (USM) – Principle, equipment, material removal mechanism, process parameters and applications.	2
2.2	Abrasive Jet Machining (AJM) – Working principle, nozzle design, abrasive materials, process parameters and applications.	2
2.3	Water Jet Machining (WJM) and Abrasive Water Jet Machining (AWJM) – System components, cutting mechanism, advantages, limitations and industrial applications.	3
	Module 3	**7**
3.1	Electrical Discharge Machining (EDM) – Principle, equipment, spark generation, dielectric fluid, tool wear and applications	2
3.2	Wire EDM – Construction, working principle and applications.	1
3.3	Electrochemical Machining (ECM) – Principle, tool design, electrolyte circulation, process parameters and applications.	2
3.4	Laser Beam Machining (LBM) – Principle, types of lasers, material removal mechanism and applications.	1
3.5	Electron Beam Machining (EBM) – Principle, equipment and industrial uses.	1
	Module 4	**7**
4.1	Introduction to additive manufacturing – Advantages and	2

	limitations – Comparison with conventional manufacturing.	
4.2	Rapid prototyping techniques - Stereo lithography - Selective Laser Sintering (SLS) - Fused Deposition Modeling (FDM) - Binder Jetting and Powder Bed Fusion, Laminated Object Manufacturing (LOM), Directed Energy Deposition (DED).	2
4.3	Process workflow in additive manufacturing – CAD model preparation – STL format – Slicing – Post processing – Applications in product development, medical implants and aerospace.	3
	Module 5	**8**
5.1	Micro-machining – Micro-EDM, Micro-ECM – Applications in MEMS	2
5.2	Nano manufacturing – Basic concepts and techniques.	2
5.3	Hybrid manufacturing processes – Laser assisted machining – Ultrasonic assisted machining.	1
5.4	Smart manufacturing – Cyber physical systems – Digital manufacturing	1
5.6	Role of AI, IoT and automation in modern manufacturing.	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Describe the need for advanced manufacturing processes over conventional methods.
2. Summarize the classification of advanced manufacturing processes.
3. Describe the classification of advanced manufacturing processes with suitable examples.
4. Discuss the limitations of conventional manufacturing and justify the need for advanced manufacturing techniques.

Course Outcome 2 (CO2):

1. Discuss the working principle of Ultrasonic Machining (USM).
2. Describe the role of process parameters in Abrasive Jet Machining (AJM).
3. Discuss the working principle and equipment of Ultrasonic Machining (USM).
4. Apply process knowledge to explain the selection of AJM or AWJM for different materials and applications.

Course Outcome 3 (CO3):

1. Illustrate the basic steps involved in additive manufacturing.

2. Summarize the working of Fused Deposition Modeling (FDM).
3. Describe the working principle and process parameters of Electrical Discharge Machining (EDM).
4. Discuss the working and applications of Laser Beam Machining (LBM) and Electron Beam Machining (EBM).

Course Outcome 4 (CO4):

1. Describe the concept of micro-machining.
2. Summarize the basics of nano-manufacturing techniques.
3. Describe the advantages and limitations of additive manufacturing.
4. Apply additive manufacturing concepts to explain its use in product development or medical applications.

a. Course Outcome 5 (CO5)

1. Interpret the concept of smart manufacturing.
2. Summarize the role of IoT in modern manufacturing.
3. Summarize micro and nano manufacturing techniques with applications.
4. Apply hybrid manufacturing concepts to explain laser-assisted or ultrasonic-assisted machining.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4P38**
Course Name: **ADVANCED MANUFACTURING TECHNIQUES**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1	Write short notes about the need for advanced manufacturing process
2	Explain about the advantages of hybrid manufacturing process
3	Write short notes about the process parameters of USM
4	Explain about the advantages and applications about AJM
5	Explain about the significance of electrolyte circulation in ECM process
6	Write short notes about material removal mechanism of LBM
7	Write short notes about the significance of additive manufacturing
8	Explain stereo lithography process
9	Write short notes about the importance of micro machining in industrial applications
10	Explain about smart manufacturing process

PART B

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

Module 1

11 Differentiate between material removal processes and material addition processes with suitable examples. (14 Marks)

OR

12 Describe the hybrid manufacturing process with neat sketches and summarize its advantages and disadvantages. (14 Marks)

Module 2

13 Describe the working principle of the abrasive jet machining (AJM) process with neat sketches. (14 Marks)

OR

14 Explain the working of the water jet machining (WJM) process with neat sketches and summarize its advantages, limitations, and applications. (14 Marks)

Module 3

15 With the help of neat labelled diagram differentiate between EDM and wire-EDM process (14 Marks)

OR

16 Explain the working principle and industrial applications of electron beam machining process. Include necessary labelled diagram. (14 Marks)

Module 4

17 Describe any two rapid prototyping techniques with the help of neat sketches. (14 Marks)

OR

18 Explain in detail about the process workflow in additive manufacturing. (14 Marks)

Module 5

19 With the help of a suitable example explain the working principle and industrial applications of a micro machining process. (14 Marks)

OR

20 Differentiate between laser-assisted machining and ultrasonic-assisted machining processes with neat labelled diagrams. (14 Marks)

B24ME4P39	SURFACE ENGINEERING AND COATING TECHNOLOGY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course provides an overview of surface engineering and coating technologies used to enhance the performance, durability, and reliability of engineering components. It introduces fundamental surface properties and their influence on material behavior, along with key degradation mechanisms such as wear, corrosion, fatigue, and erosion. The course covers various surface modification methods including mechanical, thermal, thermo-chemical, electrochemical, chemical, and physical processes, along with advanced coating techniques like thermal spraying, vapor deposition, and laser-based methods. Students will gain the knowledge to select appropriate surface treatments and understand their applications in industries such as automotive, aerospace, energy, and biomedical engineering.

Prerequisites

Nil

Course Outcomes

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

CO 1	Describe the fundamentals of surface engineering, surface integrity, wear mechanisms, and corrosion affecting engineering components. (Cognitive Knowledge Level: Understand)
CO 2	Explain mechanical and physical surface modification techniques and apply them to relate their influence on residual stress, hardness, and fatigue performance. (Cognitive Knowledge Level: Apply)
CO 3	Explain thermal and thermo-chemical surface treatment processes and apply them to determine their influence on case depth, hardness, and component life. (Cognitive Knowledge Level: Apply)
CO 4	Explain electrochemical and chemical coating processes and apply them to determine their role in corrosion protection and functional surface enhancement. (Cognitive Knowledge Level: Apply)
CO 5	Explain advanced coating technologies and apply appropriate surface engineering techniques for industrial applications. (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
CO 2	3	3	2		2						2
CO 3	3	3	2		2						2
CO 4	3	3	2	2	2						2
CO 5	3	3	3	2	2	2			2		3

Assessment Pattern

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

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1 Fundamentals of Surface Engineering (8 hours)

Introduction, Difference between bulk properties and surface properties, need of surface engineering, Surface/sub-surface regions, Surface properties, Surface integrity: Surface roughness, residual stress, microhardness, Surface degradation: Types of wear - adhesive, abrasive, corrosive, fatigue wear, Corrosion - dry & wet corrosion mechanisms, Surface fatigue and erosion, Classification of surface modification techniques: Mechanical, Thermal, Thermo-chemical, Electrochemical & chemical and Physical methods.

MODULE 2 Mechanical and Physical Surface Modification Techniques (7 hours)

Mechanical surface modification techniques: Shot peening, burnishing, surface rolling, ultrasonic impact treatment, and laser shock peening. The working principles, process parameters, equipment, advantages, limitations, and industrial applications. The effect of these processes on residual stresses, surface hardness, microstructural refinement, and fatigue strength of materials.

Physical surface modification techniques: Thermal spraying, physical vapour deposition (PVD), sputtering, evaporation methods, ion implantation, and laser surface treatment. The fundamental mechanisms involved in these processes, coating formation, adhesion mechanisms, and control of coating thickness and properties. The influence of processing parameters on coating structure, surface morphology, and functional performance. Industrial case studies and applications in aerospace, automotive and biomedical.

MODULE 3 Thermal and Thermo-Chemical Surface Treatments (7 Hours)

Thermal surface treatment techniques: Flame hardening, induction hardening, laser surface hardening, and electron beam hardening. The fundamental principles of localised heating and rapid cooling for surface hardening, process parameters, equipment used, advantages, limitations, and industrial applications.

Thermo-chemical surface treatment processes: Heat treatment, carburising, nitriding, carbonitriding, boriding, and cyaniding. The mechanisms of diffusion, process conditions, formation of hardened layers, and the influence of treatment parameters on case depth, surface hardness, and performance. The advantages, limitations, and typical industrial applications of these processes in automotive, aerospace, and machine component manufacturing.

MODULE 4 Electrochemical and Chemical Coating Processes (7 Hours)

Electrochemical surface modification processes: Electroplating - nickel plating, chromium plating, and zinc plating, electroforming, anodising, and electroless plating. The fundamentals of electrochemical reactions, electrolyte composition, current density, and deposition mechanisms. The process parameters, coating thickness control, adhesion, and industrial applications.

Chemical surface modification processes: Conversion coatings, phosphating, chromating, and sol-gel coatings. The mechanisms of coating formation, process conditions, advantages, limitations, and typical industrial applications.

MODULE 5 Advanced Coatings, Testing and Industrial Applications (7 Hours)

Advanced Coatings: Introduction to advanced coatings, Diamond Like Carbon (DLC) coatings, structure, bonding characteristics, properties - high hardness, low friction and chemical stability, and applications in cutting tools, engine components and biomedical devices. Thermal

Barrier Coatings (TBC), multilayer coating systems, bond coat and ceramic top coat, working principles and applications in gas turbines and aerospace components. Laser cladding covering principles, process parameters, advantages and industrial applications in repair and surface strengthening, Friction-based techniques such as friction surfacing and friction stir coating for producing metallurgically bonded protective layers, along with comparison with conventional coating processes and industrial applications.

Text Books

1. William D. Callister and David G. Rethwisch, *Materials Science and Engineering: An Introduction*, Wiley.
2. George E. Totten and Hong Liang, *Surface Modification and Mechanisms: Friction, Stress, and Reaction Engineering*, CRC Press.
3. A. W. Batchelor, L. N. Lam and M. Chandrasekaran, *Materials Degradation and its Control by Surface Engineering*, Imperial College Press.
4. Tadeusz Burakowski and Tadeusz Wierzchon, *Surface Engineering of Metals: Principles, Equipment, Technologies*, CRC Press.
5. K. G. Budinski, *Surface Engineering for Wear Resistance*, Prentice Hall.

Reference Books

1. ASM International, *ASM Handbook: Surface Engineering*, Vol. 5, ASM International.
2. ASM International, *Metals Handbook*, Vol. 5: *Surface Cleaning, Finishing and Coating*, ASM International.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**8**
1.1	Introduction, Difference between bulk properties and surface properties, need of surface engineering, Surface/sub-surface regions, Surface properties,	2
1.2	Surface integrity: Surface roughness, residual stress, microhardness,	2
1.3	Surface degradation: Types of wear - adhesive, abrasive, corrosive, fatigue wear, Corrosion - dry & wet corrosion mechanisms, Surface fatigue and erosion,	2
1.4	Classification of surface modification techniques: Mechanical, Thermal, Thermo-chemical, Electrochemical & chemical and Physical methods.	2
	Module 2	**7**
2.1	Mechanical surface modification techniques: Shot peening, burnishing, surface rolling, ultrasonic impact treatment, and laser shock peening.	2

2.2	The working principles, process parameters, equipment, advantages, limitations, and industrial applications. The effect of these processes on residual stresses, surface hardness, microstructural refinement, and fatigue strength of materials.	2
2.3	Physical surface modification techniques: Thermal spraying, physical vapour deposition (PVD), sputtering, evaporation methods, ion implantation, and laser surface treatment.	2
2.4	The fundamental mechanisms involved in these processes, coating formation, adhesion mechanisms, and control of coating thickness and properties. The influence of processing parameters on coating structure, surface morphology, and functional performance. Industrial case studies and applications in aerospace, automotive and biomedical.	1
	Module 3	**7**
3.1	Thermal surface treatment techniques: Flame hardening, induction hardening, laser surface hardening, and electron beam hardening.	2
3.2	The fundamental principles of localised heating and rapid cooling for surface hardening, process parameters, equipment used, advantages, limitations, and industrial applications.	2
3.3	Thermo-chemical surface treatment processes: Heat treatment, carburising, nitriding, carbonitriding, boriding, and cyaniding.	1
3.4	The mechanisms of diffusion, process conditions, formation of hardened layers, and the influence of treatment parameters on case depth, surface hardness, and performance. The advantages, limitations, and typical industrial applications of these processes in automotive, aerospace, and machine component manufacturing.	2
	Module 4	**7**
4.1	Electrochemical surface modification processes: Electroplating - nickel plating, chromium plating, and zinc plating, electroforming, anodising, and electroless plating. .	2
4.2	The fundamentals of electrochemical reactions, electrolyte composition, current density, and deposition mechanisms. The process parameters, coating thickness control, adhesion, and industrial applications.	2
4.3	Chemical surface modification processes: Conversion coatings, phosphating, chromating, and sol-gel coatings.	1
	The mechanisms of coating formation, process conditions, advantages, limitations, and typical industrial applications	2
	Module 5	**7**
5.1	Advanced Coatings: Introduction to advanced coatings, Diamond Like Carbon (DLC) coatings, structure, bonding characteristics, properties - high hardness, low friction and chemical stability, and applications in cutting tools, engine components and biomedical devices.	2
5.2	Thermal Barrier Coatings (TBC), multilayer coating systems, bond coat and ceramic top coat, working principles and applications in gas turbines and aerospace components.	2
5.3	Laser cladding covering principles, process parameters, advantages	1

	and industrial applications in repair and surface strengthening,	
5.4	Friction-based techniques such as friction surfacing and friction stir coating for producing metallurgically bonded protective layers, along with comparison with conventional coating processes and industrial applications.	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the concept of surface engineering and differentiate between bulk and surface properties of materials.
2. Describe the need for surface engineering in improving material performance.
3. Identify various surface integrity parameters such as surface roughness, residual stress and microhardness.
4. Classify different types of wear and corrosion mechanisms affecting engineering components.
5. Apply knowledge to classify suitable surface modification techniques for different engineering problems.

Course Outcome 2 (CO2):

1. Explain the working principles of mechanical surface modification techniques.
2. Describe process parameters and equipment used in shot peening, burnishing and surface rolling.
3. Explain the principles of physical surface modification processes such as thermal spraying and PVD.
4. Analyze the effect of these processes on residual stress, microstructure and fatigue strength.
5. Apply suitable mechanical or physical surface treatment methods for improving material performance in industrial applications.

Course Outcome 3 (CO3):

1. Explain the principles of thermal surface hardening techniques.
2. Describe the process parameters of flame hardening and induction hardening.
3. Explain the mechanisms involved in thermo-chemical surface treatments.
4. Compare different diffusion-based processes such as carburising and nitriding.
5. Apply suitable thermal or thermo-chemical treatments to improve hardness and wear resistance of machine components.

Course Outcome 4 (CO4):

1. Explain the principles of electrochemical surface modification processes.
2. Describe electroplating techniques such as nickel, chromium and zinc plating.
3. Explain the working principles of electroless plating and anodising.
4. Analyze the effect of electrolyte composition and current density on coating quality.
5. Apply appropriate electrochemical or chemical coating techniques for corrosion protection.

Course Outcome 5 (CO5)

1. Explain the concept and importance of advanced coatings in engineering applications.
2. Describe the structure and properties of Diamond Like Carbon (DLC) coatings.
3. Explain the working principles of Thermal Barrier Coatings (TBC).
4. Describe the principles and parameters of laser cladding and friction-based coating techniques.
5. Apply suitable advanced coating techniques for improving wear, thermal resistance and corrosion resistance in industrial components.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4P39**
Course Name: **SURFACE ENGINEERING AND COATING TECHNOLOGY**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Differentiate between bulk properties and surface properties of materials.
2. Classify surface modification techniques with suitable examples.
3. Write the principle of shot peening and mention its advantages.
4. List the physical surface modification techniques used for coating deposition.
5. Define induction hardening and state its advantages.
6. What is nitriding? Mention its industrial applications.
7. Define electroplating and mention its advantages.
8. List the chemical conversion coating processes used in surface engineering.
9. What are Diamond Like Carbon (DLC) coatings? Mention two properties.
10. Define laser cladding and state its advantages.

PART B

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

Module 1

11. Describe the concept of surface integrity and explain the roles of surface roughness, residual stress, and microhardness in determining component performance. (14 Marks)

OR

12. Classify different types of wear (adhesive, abrasive, corrosive, and fatigue wear) and describe dry and wet corrosion mechanisms with suitable examples. (14 Marks)

Module 2

13. Explain mechanical surface modification techniques such as shot peening, burnishing, ultrasonic impact treatment and laser shock peening with their advantages and applications. (14 Marks)

OR

14. Describe the principles of PVD processes (sputtering and evaporation) and explain the factors affecting coating thickness and adhesion. (14 Marks)

Module 3

15. Explain thermal surface hardening techniques such as flame hardening, induction hardening, laser hardening and electron beam hardening with suitable diagrams. (14 Marks)

OR

16. Describe thermo-chemical surface treatments such as carburising, nitriding, carbonitriding, and boriding, and explain their mechanisms and applications. (14 Marks)

Module 4

17. Explain the principle and process of electroplating and discuss nickel, chromium and zinc plating with applications. (14 Marks)

OR

18. Describe conversion coatings such as phosphating, chromating, and sol–gel coatings, and explain their mechanisms and industrial applications. (14 Marks)

Module 5

19. Explain Thermal Barrier Coatings (TBC) including bond coat, ceramic top coat and their applications in gas turbines. (14 Marks)

OR

20. Describe laser cladding, friction surfacing, and friction stir coating, and compare them with conventional coating techniques. (14 Marks)

B24ME4P41	OPTIMIZATION TECHNIQUES AND APPLICATIONS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Optimization techniques play a vital role in engineering design, planning, and decision-making by enabling engineers to determine the best possible solutions within given constraints. In mechanical engineering, optimization is widely used in areas such as design improvement, resource allocation, manufacturing processes, structural design, and system performance enhancement. This course introduces students to the fundamental principles and methods of engineering optimization, including mathematical modelling of engineering problems, calculus-based optimization techniques, and linear programming methods. The course also covers applications of optimization using computational tools and introduces advanced topics such as integer programming and multi-objective optimization. Through theoretical concepts and engineering applications, the course aims to develop the ability of students to analyze and solve practical optimization problems encountered in mechanical engineering systems.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the basic concepts of optimization and formulate engineering design problems as mathematical optimization models by identifying objective functions and constraints. (Cognitive Knowledge Level: Understand).
CO 2	Apply calculus-based optimization methods to determine optimal solutions for single-variable and multi-variable functions with constraints. (Cognitive Knowledge Level: Apply)
CO 3	Analyze linear programming problems and determine optimal solutions using graphical and simplex methods (Cognitive Knowledge Level: Analyze)
CO 4	Apply linear and integer programming techniques using computational tools to solve engineering resource allocation and planning problems. (Cognitive Knowledge Level: Apply)
CO 5	Analyze advanced optimization techniques such as multi-objective optimization and evolutionary algorithms for engineering design applications. (Cognitive Knowledge Level: Analyze).

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	20		
Understand	40	20	30
Apply	40	40	40
Analyse		40	30
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Introduction to Optimization (7 Hours)

Introduction to optimization and its importance in engineering design and decision making; engineering applications of optimization in mechanical systems; formulation of engineering design problems; art of mathematical modelling; objective functions; constraints and constraint surfaces; formulation of design problems as mathematical programming problems; classification of optimization problems; overview of optimization techniques – classical and modern optimization methods.

Module 2: Optimization using Calculus (7 Hours)

Stationary points and optimality conditions; optimization of functions of single variable; optimization of functions of multiple variables; global optimum and local optimum; convexity and concavity of functions; gradient vectors and their significance in optimization; optimization with equality constraints using Lagrangian methods; Hessian matrix and second-order optimality conditions; introduction to Kuhn–Tucker conditions; illustrative engineering examples.

Module 3: Linear Programming Fundamentals (7 Hours)

Linear programming problem formulation; standard and canonical forms of LP problems; assumptions in linear programming models; graphical method for solving two-variable LP problems; motivation for the simplex method; simplex algorithm and simplex tableau; optimality conditions; minimization and maximization problems; revised simplex method; duality in linear programming; primal–dual relationships; dual simplex method; sensitivity or post-optimality analysis.

Module 4: Applications of Linear Programming and Integer Programming (7 Hours)

Applications of linear programming in engineering problems; solving linear optimization problems using spreadsheet tools such as Excel and other optimization software; applications in transportation, assignment, resource allocation, and production planning problems; introduction to integer programming; integer linear programming models; cutting plane concept; mixed integer programming; solution approaches and engineering applications.

Module 5: Advanced Optimization Methods (8 Hours)

Introduction to multi-objective optimization; weighted sum method and ε-constraint method; concept of multi-level optimization; direct and indirect search methods; evolutionary and nature-inspired algorithms for optimization; overview of genetic algorithms and other heuristic methods; applications of advanced optimization techniques in mechanical engineering design and decision making.

Text Books

1. S. S. Rao, *Engineering Optimization: Theory and Practice*, New Age International Publishers, New Delhi.
2. Kalyanmoy Deb, *Optimization for Engineering Design: Algorithms and Examples*, Prentice Hall of India, New Delhi.

Reference Books

1. H. A. Taha, *Operations Research: An Introduction*, Pearson Education.
2. G. Hadley, *Linear Programming*, Narosa Publishing House, New Delhi.
3. K. Srinivasa Raju and D. Nagesh Kumar, *Multi-Criterion Analysis in Engineering and Management*, PHI Learning Pvt. Ltd., New Delhi.
4. Edwin K. P. Chong and Stanislaw H. Zak, *An Introduction to Optimization*, Wiley India.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Introduction to optimization; engineering applications; need for optimization	2
1.2	Mathematical modelling; objective function; constraints and constraint surface	2
1.3	Formulation of design problems; classification of optimization problems	2
	Overview of classical and modern optimization techniques; examples	1
	Module 2	**7**
2.1	Stationary points; optimization of single-variable functions	2
2.2	Optimization of multivariable functions; convexity and concavity	2
2.3	Constrained optimization using Lagrangian method	2
2.4	Hessian matrix; Kuhn–Tucker conditions; examples	1
	Module 3	**7**
3.1	Formulation of LP problems; standard and canonical forms	2
3.2	Graphical method for solving LP problems	2
3.3	Simplex method and simplex tableau	2
3.4	Duality, dual simplex method, sensitivity analysis	1
	Module 4	**7**
4.1	Applications of LP: transportation and assignment problems	2
4.2	Solving LP problems using Excel/optimization tools	2
4.3	Integer programming and mixed integer programming	2
	Cutting plane concept and applications	1
	Applications of LP: transportation and assignment problems	
	Module 5	**8**
5.1	Multi-objective optimization; weighted sum method	2
5.2	ε-constraint method; multi-level optimization	2
5.3	Direct and indirect search methods	2
5.4	Evolutionary algorithms; engineering applications; case discussion	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Define optimization and give two engineering applications.
2. What is an objective function?
3. Define constraints and constraint surface.
4. Explain the need for optimization in engineering and discuss the steps involved in formulating an optimization problem.

Course Outcome 2 (CO2):

1. Find the stationary point of $f(x)=x_2-4x+3$.
2. What is convexity of a function?
3. State the Lagrangian function.
4. Explain the optimization of single-variable and multivariable functions with suitable examples.

Course Outcome 3 (CO3):

1. Define a linear programming problem.
2. What is the standard form of an LP problem?
3. State the basic idea of the simplex method.
4. Explain the graphical method for solving linear programming problems with an example.

Course Outcome 4 (CO4):

1. What is a transportation problem?
2. Define integer programming.
3. What is mixed integer programming?
4. Explain transportation and assignment problems with suitable examples.

Course Outcome 5 (CO5)

1. Define multi-objective optimization.
2. What is the weighted sum method?
3. Define evolutionary algorithms.
4. Explain multi-objective optimization methods with suitable examples.

MODEL QUESTION PAPER

QP CODE: Pages: 4

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4P41**

Course Name: **OPTIMIZATION TECHNIQUES AND APPLICATIONS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Define constraints and constraint surface.

2 List the types of optimization problems.

3 What is convexity of a function?

4 Write the Lagrangian for maximizing f(x,y) = xy subject to x + y= 10.

5 What is the standard form of an LP problem?

6 Formulate an LP problem for maximizing profit given two products and resource constraints.

7 What is mixed integer programming?

8 Solve a simple assignment: Assign 2 jobs to 2 machines with cost matrix $\begin{bmatrix} 4 & 6 \\ 5 & 3 \end{bmatrix}$

9 Define evolutionary algorithms.

10 Write the formulation for a two-objective optimization problem.

PART B

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

Module 1

11 a. Formulate a simple optimization problem for minimizing material cost of a component. (5 marks)

b. A cylindrical pressure vessel with closed ends must store 10 m^3 volume. The material cost is proportional to the surface area. Formulate an optimization problem to minimize the material cost, considering Radius r and height h as design variables; Volume constraint: $\pi r^2 h=10$
Clearly define objective function and constraints. (9 marks)

OR

12 a. Explain the role of objective functions and constraints in engineering optimization problems. (5 marks)

b. Explain the steps involved in mathematical modelling of an engineering optimization problem. Illustrate with a suitable mechanical engineering example. (9 marks)

Module 2

13 a. Explain the role of Hessian matrix and Kuhn–Tucker conditions in optimization. (5 marks)

b. Using Lagrange multipliers, maximize:
$f(x, y) = x\,y$
Subject to:
$x + y = 12$ (9 marks)

OR

14 a. Explain the optimization of single-variable and multivariable functions with suitable examples. (5 marks)

b. Find and classify the stationary points of:
$f(x) = x^3 - 6x^2 + 9x + 1$
Also determine whether they are maxima or minima. (9 marks)

Module 3

15 a. Discuss duality in linear programming and its significance. (5 marks)

b. Solve the LP:

Maximize

$Z=3x_1+2x_2$

Subject to:

$x_1 + x_2 \leq 4$

$2x_1 + x_2 \leq 5$

$x_1, x_2 \geq 0$

After obtaining the optimal solution:

1. Determine the range of optimality for objective coefficients.
2. Analyze the effect of increasing RHS of first constraint from 4 to 6. (9 marks)

OR

16 a. Solve the following LP problem graphically:

Maximize $Z = 3x + 5y$

Subject to:

$x + 2y \leq 8$

$3x + 2y \leq 12$

$x, y \geq 0$ (5 marks)

b. For the LP problem:

Minimize

$Z = 6x_1 + 8x_2$

Subject to:

$2x_1 + x_2 \geq 8$

$x_1 + 3x_2 \geq 12$

$x1, x2 \geq 0$

1. Convert to standard form and solve using simplex.
2. Formulate the dual problem.
3. Verify strong duality and interpret the results. (9 marks)

Module 4

17 a. Discuss integer programming and its solution approaches. (5 marks)

b. Find optimal solution for the following transportation problem
Supply: $S_1 = 15$, $S_2 = 25$, $S_3 = 10$

Demand: $D_1 = 5$, $D_2 = 15$, $D_3 = 15$, $D_4 = 15$

Cost matrix:

	D_1	**D_2**	**D_3**	**D_4**
S_1	10	2	20	11
S_2	12	7	9	20
S_3	4	14	16	18

Find optimal transportation cost. (9 marks)

OR

18 a. Explain the difference between transportation and assignment problems. (5 marks)

b. Solve the following using Branch and Bound method:

Maximize

$Z = 7x_1 + 9x_2$

Subject to:

$2x_1 + 3x_2 \leq 12$

$x_1 + x_2 \leq 5$

$x_1, x_2 \geq 0$ and integers (9 marks)

Module 5

19 a. Explain the different multi-objective optimization methods. (5 marks)

b. A design problem has two objectives:
$f_1(x) = x^2$,
$f_2(x) = (x-4)^2$
Use the weighted sum method with weights $w_1=0.5$, $w_2=0.5$
to find the optimal solution. (9 marks)

OR

20 a. Discuss evolutionary algorithms and their applications in engineering optimization. (5 marks)

b. Apply the ε-constraint method to solve:
Minimize

$f_1(x, y) = x^2 + y^2$

Subject to:

$f_2(x, y) = x + y \leq 4$,

$x,y \geq 0$

Formulate and solve the problem. (9 marks)

B24ME4P42	FRACTURE MECHANICS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Fracture Mechanics is a vital area of study in Mechanical Engineering that deals with the behavior of materials containing cracks and defects. This course introduces the fundamental principles governing crack initiation and growth under different loading conditions. It provides a systematic framework to predict failure using energy-based and stress-intensity approaches. Students will gain insight into linear elastic fracture mechanics, elastic–plastic fracture behavior, fatigue crack growth, and fracture toughness evaluation. The course also emphasizes practical applications in the design and assessment of components such as pressure vessels, aircraft structures, pipelines, rotating machinery, and automotive systems. This course prepares students for careers in structural integrity assessment, failure analysis, advanced materials engineering, and research in areas such as composites, fracture in heterogeneous materials, and durability of engineering systems.

Prerequisite

Nil

Course Outcomes

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

CO 1	Describe different types of failure and Griffith's energy approach to understand fracture behavior in materials. (Cognitive Knowledge Level: Understand)
CO 2	Explain stress intensity factor and crack-tip stress fields in linear elastic fracture mechanics for crack analysis. (Cognitive Knowledge Level: Understand)
CO 3	Illustrate crack-tip plasticity, J-Integral and CTOD concepts in elastic–plastic fracture mechanics. (Cognitive Knowledge Level: Understand)
CO 4	Apply fracture toughness testing methods and fatigue crack growth principles to assess structural integrity. (Cognitive Knowledge Level: Apply)
CO 5	Identify mixed-mode crack behavior and appropriate non-destructive testing methods for crack detection. (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	–	1	1	–	–	–	–	1
CO 2	3	2	2	1	2	1	–	–	–	–	1
CO 3	3	2	2	1	2	1	–	–	–	–	1
CO 4	3	3	3	2	3	2	–	–	–	1	2
CO 5	2	2	2	1	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	40	40	40
Understand	60	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 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) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Fundamentals of fracture and energy approach (8 hours)

Introduction to fracture mechanics and its importance in mechanical engineering, Kinds of failure: ductile fracture, brittle fracture, fatigue failure, creep rupture, Characteristic features of brittle failure, Historical development of fracture mechanics, Contributions of Griffith, Concept of surface energy.

Crack growth concept, Mathematical formulation of Griffith's theory, Thin plate vs. thick plate behavior, Energy balance approach, Critical energy release rate (Gc), Limitations of Griffith's theory.

MODULE 2: Stress intensity factor and linear elastic fracture mechanics (8 hours)

Concept of Stress Intensity Factor (SIF), Modes of fracture: Mode I, Mode II, Mode III, Linear Elastic Fracture Mechanics (LEFM) assumptions, Stress and displacement fields near crack tip in isotropic elastic materials, Elementary properties of complex variables in fracture analysis, Near-tip stress singularity.

Principle of superposition, Crack in a plate of finite dimensions, Edge cracks, Embedded cracks, Geometric correction factors, Relation between energy release rate (G_I) and stress intensity factor (K_I).

MODULE 3: Crack tip plasticity and elastic–plastic fracture mechanics (7 hours)

Limitations of LEFM, Plastic deformation at crack tip, Approximate shape and size of the plastic zone, Effective crack length concept, Effect of plate thickness on plastic zone.

Relevance of Elastic–Plastic Fracture Mechanics, Definition of J-Integral, Stress–strain relations in elastic–plastic materials, Crack Tip Opening Displacement (CTOD), Equivalence between CTOD and J-Integral.

MODULE 4: Fracture testing and fatigue failure (7 hours)

Test methods KIC test techniques, Test methods to determine JIC, Test methods to determine GIC and GIIC, Determination of critical CTOD.

Fatigue terminology, S–N curve and endurance limit, Crack initiation mechanisms, Crack propagation (Paris law concept), Effect of overload, Crack closure phenomenon, Variable amplitude fatigue loading.

MODULE 5: Mixed mode fracture and crack detection techniques (6 hours)

Fracture surface characteristics, Mixed mode loading conditions, Crack growth direction prediction, Interaction of Mode I, II and III.

Importance of crack detection in structural integrity, Visual inspection, Liquid Penetrant Inspection (LPI), Magnetic particle testing, Radiographic testing, Ultrasonic testing.

Text Books

1. Prashant Kumar, *Elements of Fracture Mechanics*, McGraw Hill Education (Ind) Pvt. Ltd.
2. S. K. Maiti, *Fracture Mechanics: Fundamentals and Applications*, Cambridge University Press.

3. Ashok Saxena, *Basic Fracture Mechanics and Its Applications*, CRC Press.

Reference Books

1. T. L. Anderson, *Fracture Mechanics – Fundamentals and Applications*, CRC Press.
2. D. Broek, *Elementary Engineering Fracture Mechanics*, Springer Science & Business Media.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module1	**8**
1.1	Introduction to fracture mechanics and its importance in mechanical engineering	1
1.2	Kinds of failure: ductile fracture, brittle fracture, fatigue failure, creep rupture, Characteristic features of brittle failure	1
1.3	Historical development of fracture mechanics, Contributions of Griffith	1
1.4	Concept of surface energy, Crack growth concept	1
1.5	Mathematical formulation of Griffith's theory	1
1.6	Thin plate vs. thick plate behavior	1
1.7	Energy balance approach	1
1.8	Critical energy release rate (Gc), Limitations of Griffith's theory.	1
	Module 2	**8**
2.1	Concept of Stress Intensity Factor (SIF), Modes of fracture: Mode I, Mode II, Mode III	1
2.2	Linear Elastic Fracture Mechanics (LEFM) assumptions	1
2.3	Stress and displacement fields near crack tip in isotropic elastic materials	1
2.4	Elementary properties of complex variables in fracture analysis, Near-tip stress singularity	1
2.5	Principle of superposition	1
2.6	Crack in a plate of finite dimensions, Edge cracks	1
2.7	Embedded cracks, Geometric correction factors	1
2.8	Relation between energy release rate (G_I) and stress intensity factor (K_I)	1
	Module 3	**7**
3.1	Limitations of LEFM, Plastic deformation at crack tip	1
3.2	Approximate shape and size of the plastic zone	1
3.3	Effective crack length concept, Effect of plate thickness on plastic zone.	1
3.4	Relevance of Elastic–Plastic Fracture Mechanics, Definition of J-Integral	1

3.5	Stress–strain relations in elastic–plastic materials	1
3.6	Crack Tip Opening Displacement (CTOD)	1
3.7	Equivalence between CTOD and J-Integral.	1
	Module 4	**7**
4.1	Test methods KIC test techniques	1
4.2	Test methods to determine J_{IC}, Test methods to determine G_{IC} and G_{IIC}	1
4.3	Determination of critical CTOD.	1
4.4	Fatigue terminology, S–N curve and endurance limit	1
4.5	Crack initiation mechanisms, Crack propagation (Paris law concept)	1
4.6	Effect of overload, Crack closure phenomenon	1
4.7	Variable amplitude fatigue loading	1
	Module 5	**6**
5.1	Fracture surface characteristics, Mixed mode loading conditions	1
5.2	Crack growth direction prediction	1
5.3	Interaction of Mode I, II and III.	1
5.4	Importance of crack detection in structural integrity, Visual inspection	1
5.5	Liquid Penetrant Inspection (LPI), Magnetic particle testing, Radiographic testing, Ultrasonic testing.	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the differences between ductile and brittle fracture with neat sketches.
2. Describe Griffith's energy balance approach and explain the significance of surface energy in brittle fracture.
3. Determine the energy release rate of a DCB specimen through change in strain energy approach for constant load.

Course Outcome 2 (CO2):

1. Explain the three modes of fracture.
2. Describe the nature of the stress and displacement fields near the crack tip in LEFM.
3. Why should we evaluate the SIF for a crack in a component? How does it help a designer?

Course Outcome 3 (CO3):

1. Explain the formation of the plastic zone at the crack tip.
2. Define the J-Integral and explain the concept of path independence in elastic–plastic fracture mechanics.

3. A cracked plate made of elastic–plastic material has a yield strength of 300 MPa and a critical CTOD of 0.25 mm. Estimate the critical J-Integral value and comment on the fracture condition.

Course Outcome 4 (CO4):

1. Explain the procedure for determining plane strain fracture toughness (K_{IC}) using a standard specimen.
2. What are the limitations of S-N curve approach?
3. Sketch and explain Pari's curve.

Course Outcome 5 (CO5):

1. Define mixed-mode fracture toughness.
2. Explain the working principle of magnetic particle inspection.
3. Explain the principle of X-ray radiographic testing.

KNOWLEDGE IS POWER

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : ....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SEVENTH SEMESTER BTECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4P42**

Course Name: **FRACTURE MECHANICS**

Max. Marks: 100 Duration: 3 hours

(Any missing data may be assumed appropriately.)

PART A

Answer all questions. Each question carries 3 marks.

1. Why does the compliance of a structural component increase as the crack length increases?
2. Why are thin plates tougher in comparison to thick plates?
3. What is meant by a singularity? What type of singularity characterizes the stress field in the vicinity of a crack tip in Linear Elastic Fracture Mechanics (LEFM)?
4. Why is an edge crack considered more critical than a centre crack of the same length?
5. Explain the effect of plate thickness on crack-tip plasticity.
6. Write down the relationship between J Integral and CTOD.
7. What is a J–R curve?
8. Explain how the application of an overload affects the propagation of a fatigue crack.
9. What is mixed-mode loading? Give practical engineering examples.
10. What are the limitations of radiographic imaging?

PART B

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

Module 1

11. Discuss the different kinds of material failure and explain the limitations of conventional failure theories in predicting brittle fracture. (14 Marks)

OR

12. A large plate of 36 mm thickness with an edge crack of a = 32 mm length is pulled very slowly under displacement control loading. At the displacement of 7.2 mm, when the

recorded load is 2750 N, the crack starts growing. At a= 41.7 mm, the crack is arrested and the load decreases to 1560 N. Determine the critical energy release rate. (14 marks)

Module 2

13. Determine the critical crack length in a centered-cracked plate, loaded in Mode I, if critical stress intensity factor K_{IC} = 50 MPa√m and far field stress is 100 MPa. (14 marks)

OR

14. A steel plate of width 200 mm and thickness 10 mm contains a single edge crack of length a = 25 mm. The plate is subjected to a uniform tensile stress of 120 MPa. Determine the Mode I Stress Intensity Factor K_I for the edge crack using the appropriate geometric correction factor for a finite width plate. If the plane strain fracture toughness of the material is K_{IC} = 45 MPa√m, determine whether the crack will propagate. (14 marks)

Module 3

15. Apply Irwin's plastic zone correction to determine the stress intensity factor (SIF), the effective crack length, and the plastic zone size for a single edge crack of length 18 mm in a plate of width 90 mm. The plate thickness is 6 mm and it is subjected to a uniform far-field tensile stress of 160 MPa. The yield strength of the material is 360 MPa. (14 marks)

OR

16. Prove that the J Integral is path independent. (14 Marks)

Module 4

17. Discuss the procedure for determining critical CTOD and its significance in elastic–plastic fracture mechanics. (14 Marks)

OR

18. To find material constants for Paris law, it was found that an already nucleated centre crack grows from 2a= 5.6 mm to 2a= 7 mm in 10,000 cycles of a constant amplitude load. When the same load is continued, the crack grows from 2a = 32 mm to 2a = 36.8 mm in 1400 cycles. If σmax = 180 MPa and σmin = 90 MPa, find the constants C and m. (14 Marks)

Module 5

19. Discuss the behavior of cracks under mixed-mode loading conditions. Explain how the interaction of Mode I, Mode II, and Mode III influences fracture surface characteristics and crack growth direction. (14 Marks)

OR

20. Explain magnetic particle inspection in detail. Why it is restricted to ferromagnetic materials? (14 marks)

B24ME4P43	PRESSURE VESSEL AND PIPING DESIGN	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces the principles and practices involved in the analysis and design of pressure vessels and piping systems used in industrial applications. Emphasis is placed on understanding stress behavior under various loading conditions, including internal pressure, external pressure, wind, and seismic effects. The course integrates fundamental mechanics with design methodologies guided by relevant codes such as ASME Section VIII and piping standards like ASME B31. Through analytical approaches and code-based procedures, students develop the ability to evaluate structural integrity, design safe components, and understand real-world engineering constraints in pressure-containing systems. The course also familiarizes students with standard components, manufacturing considerations, and flexibility analysis required for reliable piping network design.

Prerequisites

Nil

Course Outcomes

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

CO1	Understand the design considerations of various shell-type pressure vessels. (Cognitive Knowledge Level: Understand)
CO2	Understand the design considerations of thick cylinders under various kinds of loadings. (Cognitive Knowledge Level: Understand)
CO3	Apply design concepts in the design of shell and supports of vertical and horizontal pressure vessels and solve problems involving the thickness and stiffener support requirements of cylinders under buckling loads. (Cognitive Knowledge Level: Apply)
CO4	Understand pipe, pipe size, pipe thickness, piping components and manufacturing. (Cognitive Knowledge Level: Understand)
CO5	Solve problems involving stress analysis, sizing and thickness calculation of pipes. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2								1
CO2	3	2	2	1							1
CO3	3	3	2	2							1
CO4	3	2	2	2							1
CO5	3	3	2	2							1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	20	10
Understand	60	40	50
Apply		40	40
Analyse			
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance :10 marks
Continuous Assessment Test (2 numbers) :25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Fundamentals of Pressure Vessels and Membrane Stresses Analysis (8 hours)

Pressure vessel: Pressure vessel, Terminology, Types of loads, Types of pressure, Types of supports, Stresses in pressure vessels, Dilation of pressure vessels, Membrane stress analysis of vessel shell components, cylindrical shells, Spherical shells, torus, Conical head, Elliptical head, (Familiarisation of corresponding ASME section 8 codes for membrane stress equations) Discontinuity stress analysis in pressure vessels.

MODULE 2: Thick Cylinder Theory and Reinforced Openings (9 hours)

Stresses in thick-walled cylinders: Stresses in thick-walled cylinders –Lame's equation for internal and external pressure, Shrink-fit stresses in Built up cylinders, auto frettage of thick cylinders. Theory of reinforced opening (Familiarisation of corresponding ASME section 8 codes for reinforcement analysis.

MODULE 3: Design of Tall Vessels and Stability Considerations (6 hours)

Design of tall vessel under wind and seismic load: Design of tall vessel under wind and seismic load. Design of leg, lug and saddle supports. Buckling -Analysis of Elastic buckling of cylinders or pipes under external pressure- Design of Stiffeners for pressure vessel

(Use relevant ASME codes and standard practices in pressure vessel design for the entire third module)

MODULE 4: Piping Systems and Components (5 hours)

Pipes - classification, applications - Size specification, nominal pipe size, schedules, wall thickness - Manufacturing techniques, seamless, welded, ERW - Piping components - bends, elbows, tees, reducers, flanges, valves, bellows

MODULE 5: Stress Analysis and Flexibility of Piping Systems (8 hours)

Stress Analysis, sizing and thickness calculation of pipes: Stress Analysis, sizing and thickness calculation of pipes (Familiarise with ASME B31.3). Allowable and displacement stress range for expected cyclic life-stress intensification factor- Flexibility Analysis (Analysis as per clause 119.7.1 in Code ASME B31.1/clause 319.4.1 in ASME B31.3 only).

Text Books

1. John F. Harvey, *Theory and Design of Pressure Vessels,* CBS Publisher and Distributers.
2. Somnath Chathopadhyay, *Pressure Vessels Design and Practice,* CRC Press.
3. Brownell L. E. and Young E. H., *Process Equipment Design*, John Wiley and Sons
4. Eugene R Megyesy, *Pressure Vessel Design Hand Book*, Pressure Vessel Design Hand Book.

Reference Books

1. Dennis R.Moss and Michael Basic, *Pressure Vessel Design Manual*, Elsevier Inc.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**8**
1.1	Pressure vessel, Terminology, Types of loads, Types of pressure, Types of supports.	2
1.2	Stresses in pressure vessels, Dilation of pressure vessels, Membrane stress analysis of vessel shell components.	2
1.3	Cylindrical shells, Spherical shells, torus, Conical head, Elliptical head, (Familiarisation of corresponding ASME section 8 codes for membrane stress equations).	2
1.4	Discontinuity stress analysis in pressure vessels.	2
	Module 2	**9**
2.1	Stresses in thick-walled cylinders –Lame's equation for internal and external pressure.	3
2.2	Shrink-fit stresses in Built up cylinders, auto frettage of thick cylinders.	3
2.3	Theory of reinforced opening (Familiarisation of corresponding ASME section 8 codes for reinforcement analysis.	3
	Module 3	**6**
3.1	Design of tall vessel under wind and seismic load. Design of leg, lug and saddle supports.	2
3.2	Buckling -Analysis of Elastic buckling of cylinders or pipes under external pressure- Design of Stiffeners for pressure vessel (Use relevant ASME codes and standard practices in pressure vessel design for the entire third module).	4
	Module 4	**5**
4.1	Size and wall thickness specification, Type of pipes based on manufacturing technique.	2
2	Piping components - bends, tees, elbows, reducers, bellows, flanges and valves.	3
	Module 5	**8**
5.1	Stress Analysis, sizing and thickness calculation of pipes (Familiarise with ASME B31.3).	3
5.2	Allowable and displacement stress range for expected cyclic life-stress intensification factor.	3
5.3	Flexibility Analysis (Analysis as per clause 119.7.1 in Code ASME B31.1/clause 319.4.1 in ASME B31.3 only).	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Identify and describe the primary methods used to determine stresses in pressure vessels.
2. Apply knowledge of stress analysis and terminology to real-world pressure vessel applications.
3. Explain the importance of pressure vessel design in industrial safety and reliability.

Course Outcome 2 (CO2):

1. Explain the fundamental difference in stress distribution between thin and thick-walled cylinders. Differentiate between Eulerian and Lagrangian methods of representing fluid motion.
2. How do the radial and hoop stresses vary across the wall thickness of a thick cylinder under internal pressure?
3. Why is the hoop stress maximum at the inner radius of a thick-walled cylinder?

Course Outcome 3 (CO3):

1. What are the different types of stresses acting on a tall vertical vessel?
2. Why are wind and seismic loads typically not considered to act simultaneously in tall vessel design?
3. Explain the primary function of stiffening rings in vessels subjected to external pressure.

Course Outcome 4 (CO4):

1. Explain the difference between nominal pipe size and outside diameter. At what size do they become identical?
2. Name three critical measurements used to specify a pipe and explain why wall thickness is vital for industrial applications.
3. Explain the purpose of concentric and eccentric reducers and where each is preferred.

Course Outcome 5 (CO5)

1. Identify three main stress categories evaluated in ASME B31.3 piping stress analysis and name one typical load associated with each.
2. Explain the pressure design thickness formula for straight pipe under internal pressure as per ASME B31.3 ($t < d/6$). Define all variables involved.
3. How is stress range reduction factor determined? What is its significance in cyclic life?

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.:.....

Name:.....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4P43**

Course Name: **PRESSURE VESSEL AND PIPING DESIGN**

Max.Marks:100 Duration:3 hours

PARTA

Answer all questions. Each question carries 3 marks.

1	Explain the fundamental difference in stress distribution between thin and thick-walled cylinders.	
2	Explain the importance of pressure vessel design in industrial safety and reliability.	
3	Explain the fundamental difference in stress distribution between thin and thick-walled cylinders.	
4	Why is the hoop stress maximum at the inner radius of a thick-walled cylinder?	
5	What are the different types of stresses acting on tall vertical vessel?	
6	Explain the primary function of stiffening rings in vessels subjected to external pressure.	
7	Name three critical measurements used to specify a pipe and explain why wall thickness is vital for industrial applications.	
8	Explain the purpose of concentric and eccentric reducers and where each is preferred.	
9	Identify three main stress categories evaluated in ASME B31.3 piping stress analysis and name one typical load associated with each.	
10	How stress range reduction factor determined? What is its significance in cyclic life?	

PART B

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

Module 1

11	Design a horizontal cylindrical pressure vessel with a torispherical head to store liquid propane. Internal diameter = 2000 mm, Internal design pressure = 2.5 MPa., Material SA-516 Grade 70 (allowable tensile stress = 138 MPa), Joint efficiency = 0.85, Corrosion allowance = 3 mm.	(14 marks)

OR

12 Design cylindrical shell and elliptical head for a pressure vessel with an internal diameter of 2000 mm, internal pressure of 2 MPa, allowable stress of 150 MPa and a joint efficiency of 1.0. (14 marks)

Module 2

13 A thick-walled hydraulic cylinder is to be designed for an internal pressure of 80 MPa. The internal diameter is 150 mm. if the maximum hoop stress is limited to 120 MPa.

i. Calculate wall thickness required
ii. Find the maximum stress in the cylinder wall
iii. Determine the change in thickness if E = 200 GPa and $\upsilon = 0.3$ (14 marks)

OR

14 A compound cylinder is formed by shrinking a tube of 250 mm internal diameter and 25 mm wall thickness onto another tube of 250 mm external diameter and 25 mm wall thickness, both tubes being made of the same material. The stress set up at the junction owing to shrinkage is 10 MN/m^2. The compound tube is then subjected to an internal pressure of $80MN/m^2$. Compare the maximum hoop stress developed with that of a single cylinder of 300 mm external diameter and 50 mm thickness subjected to the same internal pressure. (14 marks)

Module 3

15 A stainless-steel vertical storage vessel of height 10 m and diameter 1.5 m is supported on four legs (bracketed support) at a height of 2 m from the ground. It contains a liquid with a density of 1000 kg/m^3. The total operating weight = 150 kN, Seismic Coefficient = 0.12 and wind speed = 100 km/hr.

i. Calculate the maximum seismic overturning moment at the base.
ii. Calculate the vertical load on each lug due to operating weight and bending moment. (14 marks)

OR

16 A vertical pressure vessel of 2000 mm outside dia and 6000 mm tangent to tangent length is subjected to an external pressure of 0.5 MPa at a design temperature of 200^0C. The material is SA-516 grade 70 (Yield strength = 260 MPa at 200^0C). Assuming a corrosion allowance of 3 mm, determine the minimum thickness required for a cylindrical shell using ASME Section VIII Div. 1 rules. (14 marks)

Module 4

17 a. Explain the nomenclature used for specifying pipe sizes. (4 marks)

b. Classify pipes based on manufacturing techniques, highlighting manufacturing processes, advantages and typical applications. (10 marks)

OR

18 a. Classify flanges based on their pipe attachment methods. (6 marks)

b. What are the essential parameters a piping engineer must address when selecting a valve for a specific process service. (8 marks)

Module 5

19 A piping segment with an outside diameter of 325 mm and a wall thickness of 10 mm is subjected to an internal pressure of 3.5 MPa. The pipe material is A106 Gr. B. The bending moment due to weight is 15 kNm and the bending moment due to wind load is 10 kNm. Assume a section modulus Z of 790 cm^3 and a stress intensification factor of 1.0.

i. Calculate the longitudinal stress due to sustained load. (7 marks)

ii. Calculate total stress due to occasional loads and verify compliance. (7 marks)

OR

20 A piping system contains a welded T junction. The header nominal thickness is 10 mm and the branch outside diameter is 200 mm. Discuss the procedure to calculate in-plane and out-plane stress intensification factor if the component is unreinforced, specifically mentioning which code and appendix is referenced for these factors. (14 marks)

B24ME4P44	FUNDAMENTALS OF UNMANNED AERIAL VEHICLES (UAV)	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces senior undergraduate students to the fundamental principles of Unmanned Aerial Vehicles (UAVs) covering both Fixed-Wing and Multi-Rotor platforms. It integrates aerodynamics, flight mechanics, avionics, guidance, navigation and control, along with an exposure to AI-based navigation and UAV data analytics. The course prepares students to analyze, design, and evaluate UAV systems for modern industrial, research, and autonomous applications.

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Prerequisites

Nil.

Course Outcomes

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

CO 1	Describe the classification, components, and operating principles of fixed-wing and multi-rotor UAVs. (Cognitive Knowledge Level: Understand)
CO 2	Apply aerodynamic principles to analyse the performance characteristics of fixed-wing UAVs. (Cognitive Knowledge Level: Apply)
CO 3	Apply principles of thrust generation, power requirements, and stability in the analysis of multi-rotor UAVs. (Cognitive Knowledge Level: Apply)
CO 4	Apply guidance, navigation, control, and AI-assisted navigation concepts in UAV systems. (Cognitive Knowledge Level: Apply)
CO 5	Explain UAV data processing workflows, regulatory aspects, and emerging autonomous 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	3	2	2	1					1	
CO 2	3	2	2	1	2					1	
CO 3	3	3	2	1	2					1	
CO 4	3	3	2	2	2					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	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Introduction to UAV Systems (7 hours)

History and evolution of UAVs. Classification: Fixed-Wing, Multi-Rotor, Hybrid VTOL. System architecture: Airframe, propulsion, avionics, payloads, ground control station. Comparison of fixed-wing vs multi-rotor platforms. Applications in agriculture, mapping, surveillance, disaster management, logistics, and defense.

MODULE 2: Aerodynamics and Performance of Fixed-Wing UAVs (7 hours)

Airfoil characteristics, lift and drag estimation. Finite wing effects, induced drag. Low-Reynolds-number aerodynamics for small UAVs. Performance parameters: stall speed, glide, climb, range and endurance estimation. Aerodynamic centre and c.g estimation. Preliminary sizing considerations.

MODULE 3: Multi-Rotor Aerodynamics and Electric Propulsion (7 hours)

Momentum theory for rotors. Thrust and power estimation. Brushless DC motors, ESCs, Li-Po batteries and power budgeting. Quadrotor configuration and control via differential thrust. Hover, climb, payload capacity and endurance estimation.

MODULE 4: Guidance, Navigation, and Control (8 hours)

Introduction to UAV Navigation: What Is Navigation, Position Fixing, Dead Reckoning. Inertial Navigation. Stability and control principles: Overview of GNC system architecture. Open-loop vs. closed-loop control, Waypoint navigation, (A* and Dijkstra's algorithms-concept only), Simultaneous Localisation and Mapping (SLAM) principles. Introduction to AI-based navigation: Deep learning for object detection, Reinforcement learning in UAV control, UAV-to-Ground communication, Swarm communication protocols.

MODULE 5: UAV Data Processing, Regulations and Emerging Trends (7 hours)

Overview of UAV regulations and safety protocols. Drone data acquisition workflow. Introduction to photogrammetry and Structure-from-Motion (concept). Basic image processing for UAV data (RGB and thermal). Introduction to UAV data analytics, NDVI concept for agriculture (introductory). Future trends in autonomous aerial mobility.

Reference Books

1. Austin, Reg, *Unmanned Aircraft Systems: UAVS Design, Development and Deployment,* Wiley.
2. Anderson, John D. Jr., *Introduction to Flight,* McGraw-Hill Education.
3. Beard, Randal W. and McLain, Timothy W., Small *Unmanned Aircraft: Theory and Practice*, Princeton University Press.
4. Fahlstrom, Paul G. and Gleason, Thomas J., *Introduction to UAV Systems*, Wiley-Inter science.
5. Camps-Valls, Gustau; Tuia, Devis; Bruzzone, Luca; Zhu, Xiao Xiang, *Remote Sensing Image Processing*, Morgan & Claypool Publishers.

COURSE CONTENT AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	UAV Evolution & Classification - History, development, types (fixed-wing, multi-rotor, hybrid VTOL)	2
1.2	UAV System Architecture - Airframe, propulsion, avionics, payloads, ground control station	3
1.3	Comparison & Applications - Fixed-wing vs multi-rotor - Applications in agriculture, mapping, surveillance, disaster management, logistics, defense.	2
	Module 2	**7**
2.1	Airfoil & Aerodynamics - Airfoil characteristics, lift and drag estimation, finite wing effects, induced drag, low Reynolds number effects *(3)*	3
2.2	Flight Performance - Stall speed, glide, climb, range and endurance estimation *(2)*	2
2.3	Stability & Preliminary Design - Aerodynamic centre, CG estimation, preliminary sizing considerations *(2)*	2
	Module 3	**7**
3.1	Rotor Aerodynamics - Momentum theory, thrust and power estimation	2
3.2	Electric Propulsion Systems - BLDC motors, ESCs, Li-Po batteries, power budgeting	3
3.3	Quadrotor Control & Performance - Differential thrust control, hover, climb, payload and endurance estimation	2
	Module 4	**8**
4.1	Navigation Fundamentals - Position fixing, dead reckoning, inertial navigation.	2
4.2	GNC Systems - Stability and control, open-loop vs closed-loop control, waypoint navigation.	2
4.3	Path Planning & SLAM - A* and Dijkstra algorithms (concept), SLAM principles.	2
4.4	AI & Communication - AI-based navigation, reinforcement learning, UAV-to-ground communication, swarm protocols.	2
	Module 5	**7**
5.1	Regulations & Safety - UAV regulations, operational safety protocols	2
5.2	Data Acquisition & Processing - Workflow, photogrammetry, Structure-from-Motion, basic image processing	2
5.3	Data Analytics & Trends - NDVI concept, agricultural applications, future trends in autonomous aerial mobility	3
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the evolution of UAVs and classify UAVs based on platform type, size, and application.
2. Explain the overall architecture of a UAV system with a neat block diagram.
3. Compare fixed-wing and multi-rotor UAVs in terms of performance characteristics and discuss their applications in fields such as agriculture, surveillance, and logistics.

Course Outcome 2 (CO2):

1. Explain the fundamentals of airfoil aerodynamics, including lift generation, lift and drag coefficients
2. Solve the key performance parameters of fixed-wing UAVs such as stall speed, glide, climb, range, and endurance.
3. Explain the concepts of aerodynamic centre and centre of gravity and their role in UAV stability.

Course Outcome 3 (CO3):

1. Solve thrust and power generation in rotors and discuss the effect of disk loading and propeller parameters.
2. Discuss the role of BLDC motors, ESCs, propellers, and Li-Po batteries, and explain the concept of power budgeting.
3. Evaluate the performance parameters such as hover, climb, payload capacity, and endurance.

Course Outcome 4 (CO4):

1. Explain the fundamentals of UAV navigation, including position fixing, dead reckoning, and inertial navigation.
2. Explain modern UAV navigation methods such as radio navigation, GPS, and vision-based navigation.
3. Explain the GNC architecture of a UAV and distinguish between open-loop and closed-loop control**.**

Course Outcome 5 (CO5):

1. Explain the UAV regulations in India including drone classification, Digital Sky platform, and airspace categories.
2. Describe the concept of Structure-from-Motion and basic image processing steps used in UAV data analysis.
3. Discuss the emerging trends in UAV systems including autonomous aerial mobility and integration with modern technologies.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4P44**

Course Name: **FUNDAMENTALS OF UNMANNED AERIAL VEHICLES (UAV)**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1	Discuss the key differences between fixed-wing, multi-rotor, and hybrid UAVs.
2	Describe the major subsystems including airframe, propulsion, avionics, payload, and ground control station.
3	Discuss the factors affecting maximum range and endurance.
4	Describe the preliminary sizing process of a fixed-wing UAV based on mission requirements.
5	Explain the components of an electric propulsion system used in multi-rotor UAVs.
6	Explain the configuration and control of a quadrotor using differential thrust.
7	Distinguish between navigation, guidance, and control.
8	Discuss the need for sensor fusion in UAV navigation systems.
9	Explain the concept of NDVI and its application in agriculture.
10	Explain the UAV data acquisition process and the principles of photogrammetry.

PART B

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

Module 1

11	Discuss different UAV platforms such as fixed-wing, multi-rotor, and hybrid VTOL, and compare their characteristics and applications. (14 Marks)

OR

12	Describe the major subsystems including airframe, propulsion, avionics, payload, and ground control station, and explain their roles in UAV operation. (14 Marks)

Module II

13 A fixed-wing UAV of weight 50 N flies at a velocity of 15 m/s in air with density 1.225 kg/m³ and wing area of 0.8 m². The lift coefficient is 0.8 and drag coefficient is 0.05.

(a) Calculate the lift and drag forces acting on the UAV. (5 marks)
(b) Determine whether the UAV can maintain steady level flight. (5 marks)
(c) Explain how low Reynolds number conditions would affect the aerodynamic performance of this UAV. (4 marks)

OR

14 A fixed-wing UAV is designed to carry a payload with a total weight of 80 N. The maximum lift coefficient is 1.2 and air density is 1.225 kg/m³. Assume a wing loading of 100 N/m².

(a) Estimate the wing area required for the UAV. (5 marks)
(b) Calculate the stall speed of the UAV. (5 marks)
(c) Discuss how the centre of gravity location and wing loading influence the stability and performance of the UAV. (4 marks)

Module III

15 Discuss how differential thrust is used to control roll, pitch, yaw, and altitude, and explain the factors affecting payload capacity and endurance. (14 Marks)

OR

16 A quadrotor UAV has a total mass of 4 kg. Each rotor has a diameter of 0.3 m. Assume air density is 1.225 kg/m³.

(a) Calculate the total thrust required for hover. (3 marks)
(b) Estimate the thrust required per rotor. (3 marks)
(c) Using momentum theory, estimate the induced velocity at the rotor disk. (4 marks)
(d) Calculate the ideal power required for hover. (4 marks)

Module IV

17 A UAV is required to navigate autonomously from a starting point to a target location in an environment with obstacles and intermittent GPS signal loss.

(a) Explain how the UAV can estimate its position using dead reckoning and inertial
(b) navigation during GPS loss. (3 marks)
(c) Suggest a suitable path planning method and justify your choice. (3 marks)
(d) Explain how waypoint navigation and error correction help the UAV follow the planned path. (4 marks)
Discuss the role of sensor fusion in improving navigation accuracy. (4 marks)

OR

18 Explain the overall Guidance, Navigation, and Control (GNC) architecture of a UAV. Distinguish between open-loop and closed-loop control systems. (14 Marks)

Module V

19 A UAV operator plans to conduct an aerial survey of an agricultural field located near a small town.

(a) Explain the regulatory requirements for operating the UAV in India, including registration on the Digital Sky platform and airspace classification. (4 marks)
(b) Identify whether the operation falls under red, yellow, or green zone and justify your answer. (4 marks)
(c) Describe the role of ATC and the permissions required for the mission. (3 marks)
(d) Discuss the safety protocols to be followed before and during the flight.(3 marks)

OR

20 Describe the concept of Structure-from-Motion (SfM) and basic image processing steps. Further, explain the NDVI concept and discuss its applications in agriculture (14 Marks)

B24ME4P45	REFRIGERATION AND CRYOGENICS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces the fundamental principles of refrigeration, cryogenic engineering, and gas liquefaction systems used in modern engineering applications. It covers thermodynamic aspects of refrigeration cycles, including air and vapour compression systems, along with methods to improve performance. The course also includes vapour absorption systems, properties and environmental aspects of refrigerants, and fundamentals of cryogenic engineering such as low-temperature material behavior and applications. It further addresses gas liquefaction technologies and systems for gases like hydrogen and helium, enabling students to apply these concepts for efficient and sustainable engineering solutions.

Prerequisites:

Nil

Course Outcomes

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

CO 1	Explain the basic principles and thermodynamic cycles of refrigeration systems including reversed Carnot and air refrigeration systems. (Cognitive Level: Understand)
CO 2	Analyze vapour compression refrigeration systems using T–s and P–h diagrams and evaluate the effect of operating parameters on COP. (Cognitive Level: Apply)
CO 3	Describe the working principles of vapour absorption refrigeration systems and compare them with vapour compression systems. (Cognitive Level: Understand)
CO 4	Identify different refrigerants, their properties, environmental impacts (ODP, GWP), and basic refrigerant handling practices. (Cognitive Level: Understand)
CO 5	Explain the fundamentals of cryogenic engineering and the working principles of various gas liquefaction systems. (Cognitive 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						1		
CO 2	3	3	1	1					1		
CO 3	2	2	1	2			2		1		
CO 4	2	1	2	1					1		
CO 5	3	2	1	2					1		

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	20	40	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Refrigeration Fundamentals (6 hours)

Introduction –Applications of refrigeration. Thermodynamics of refrigeration- reversed Carnot cycle, Limitations, heat pump, COP, Unit of refrigeration- Air refrigeration systems-Bell Coleman cycle, Air craft refrigeration systems, Boot strap system. Numerical problems.

MODULE 2: Vapour Compression Systems (7 hours)

Vapour compression systems- T- s and P- h Diagrams. Effect of operating parameters on COP – methods of improving COP of simple cycle- super- heating, under cooling, Liquid suction heat exchanger, actual cycle. Inter cooling - flash inter cooling and flash gas removal- numerical problems.

MODULE 3: Vapour Absorption Systems and Refrigerants (8 hours)

Vapour absorption systems - Ammonia – water system - simple system- drawbacks-Lithium Bromide water system- Electrolux- comparison with vapour compression system. Applications, relative merits and demerits.

Refrigerants and their properties, CFC, HCFC, HFC, HC refrigerants -Eco-friendly Refrigerants, ODP, GWP, selection of refrigerants for different applications**.** Refrigerant leakage and detection – charging of refrigerant.

MODULE 4: Fundamentals of Cryogenic Engineering (7 hours)

Introduction to cryogenic engineering, Historical background - Major events in the development of cryogenic engineering, Low Temperature properties of Engineering Materials - Mechanical properties- Thermal properties- Electric and magnetic properties, Cryogenic fluids and their properties. Applications of cryogenics: Applications in space, food processing, super conductivity, electrical power, biology, medicine, electronics and cutting tool industry- Super insulations, vacuum insulation, powder insulation.

MODULE 5: Gas Liquefaction Systems and Technologies (8 hours)

Liquefaction systems – System performance parameters, ideal liquefaction system, Joule-Thomson expansion, Adiabatic expansion, Liquefaction systems for gases other than Neon. Hydrogen and Helium. Simple Linde - Hampson system, Claude & Cascaded System.

Liquefaction systems for Neon. Hydrogen and Helium – LN2 precooled Linde Hampson and Claude systems, Ortho to Para conversion arrangement in hydrogen liquefaction system, Simon Helium liquefaction system, Collins Helium liquefaction system. Critical components of Liquefaction systems – critical components and their effect on system performance.

Text Books

1. C. P Arora, *Refrigeration and Airconditioning*, McGraw Hill Education.
2. Arora S. C. and S. Domkundwar, *Refrigeration and air conditioning*, Dhanpat Rai & Co.
3. C P Kothandaraman, *Refrigerant Tables and Charts including Air Conditioning Data*, New Age International.
4. Mamata Mukhopadhyay, *Fundamentals of Cryogenic Engineering*, PHI.

Reference Books

1. Roy J. Dossat, *Principles of Refrigeration*, Pearson
2. Manohar Prasad, *Refrigeration and Airconditioning*, New Age International.
3. Randall F. Barron, *Cryogenic Systems*, OUP USA

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**6**
1.1	Introduction –Applications of refrigeration. Thermodynamics of refrigeration, reversed Carnot cycle	1
1.2	Limitations, heat pump, COP, Unit of refrigeration- Air refrigeration systems	2
1.3	Bell Coleman cycle, Air craft refrigeration systems, Boot strap system	2
1.4	Numerical Problems	1
	Module 2	**7**
2.1	Introduction to Vapour Compression Refrigeration System – Basic components, working principle, and representation of the cycle on T–s and P–h diagrams.	2
2.2	Performance of VCR System – Effect of operating parameters such as evaporator temperature, condenser temperature, superheating, and subcooling on COP.	1
2.3	Methods of Improving COP – Superheating, subcooling, Liquid–Suction Heat Exchanger, and discussion of the actual vapour compression cycle.	2
2.4	Multistage Compression and Intercooling – Concept of intercooling, flash intercooling, and flash gas removal.	1
2.5	Numerical Problems related to vapour compression refrigeration systems.	1
	Module 3	**8**
3.1	Introduction to Vapour Absorption Refrigeration System – Working principle and Ammonia–Water system, simple system and its drawbacks.	2
3.2	Lithium Bromide–Water System and Electrolux Refrigerator – Construction and working principles.	2
3.3	Comparison with Vapour Compression System – Applications, relative merits and demerits of vapour absorption systems.	1
3.4	Refrigerants and Their Properties – Classification of refrigerants: CFC, HCFC, HFC, and HC refrigerants, eco-friendly refrigerants, and environmental aspects such as ODP and GWP.	2
3.5	Refrigerant Handling – Selection of refrigerants for different applications, refrigerant leakage detection and charging of refrigerants.	1

	Module 4	**7**
4.1	Introduction to Cryogenic Engineering – Definition, importance, historical background, and major events in the development of cryogenic engineering.	2
4.2	Low Temperature Properties of Engineering Materials – Mechanical properties and thermal properties at cryogenic temperatures.	2
4.3	Electrical and Magnetic Properties of Materials at Low Temperatures and Cryogenic Fluids and their Properties.	2
4.4	Applications of Cryogenics – Applications in space, food processing, superconductivity, electrical power, biology, medicine, electronics, and cutting tool industry.	1
	Module 5	**8**
5.1	Introduction to Liquefaction Systems – System performance parameters, ideal liquefaction system, Joule–Thomson expansion and adiabatic expansion.	2
5.2	Basic Liquefaction Systems – Liquefaction systems for gases other than Neon, Hydrogen and Helium; Simple Linde–Hampson system, Claude system and Cascaded system.	2
5.3	Liquefaction Systems for Neon, Hydrogen and Helium – LN_2 pre-cooled Linde–Hampson and Claude systems.	2
5.4	Special Arrangements in Gas Liquefaction – Ortho to Para conversion in hydrogen liquefaction, Simon Helium liquefaction system and Collins Helium liquefaction system.	1
5.5	Critical Components of Liquefaction Systems – Major components and their effect on overall system performance.	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the reversed Carnot refrigeration cycle with the help of a T–s diagram and discuss its limitations in practical refrigeration systems.
2. Explain the Bell–Coleman air refrigeration cycle with a neat schematic and T–s diagram.
3. Explain the working principle of aircraft refrigeration systems with suitable diagrams.

Course Outcome 2 (CO2):

1. Explain the vapour compression refrigeration cycle with the help of T–s and P–h diagrams.
2. Discuss the effect of operating parameters such as evaporator temperature, condenser temperature, superheating and subcooling on COP.
3. Explain the methods of improving COP in vapour compression refrigeration systems such as superheating, subcooling and liquid–suction heat exchanger.

Course Outcome 3 (CO3):

1. Explain the Ammonia–Water vapour absorption refrigeration system with a neat schematic diagram.
2. Compare vapour absorption and vapour compression refrigeration systems in terms of working principle, advantages and limitations.
3. Discuss the classification of refrigerants and explain the environmental parameters ODP and GWP.

Course Outcome 4 (CO4):

1. Explain the historical development of cryogenic engineering and the important milestones in its development.
2. Discuss the low temperature properties of engineering materials including mechanical and thermal properties.
3. Explain the applications of cryogenic engineering in space, medicine, superconductivity and electronics.

Course Outcome 5 (CO5):

1. Explain the Linde–Hampson liquefaction system with a neat schematic diagram.
2. Describe the Claude liquefaction system and explain its advantages over the Linde system.
3. Discuss the critical components of gas liquefaction systems and their influence on system performance.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4P45**

Course Name: **REFRIGERATION AND CRYOGENICS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Define Coefficient of Performance (COP) of a refrigeration system.
2 What is the Unit of Refrigeration (Ton of Refrigeration)?
3 What is superheating in a vapour compression refrigeration system?
4 What is the function of a liquid–suction heat exchanger?
5 List any three desirable properties of a refrigerant.
6 What is meant by ODP and GWP of refrigerants?
7 What is cryogenic engineering?
8 List any three applications of cryogenics.
9 What is Joule–Thomson expansion?
10 Define an ideal liquefaction system.

PART B

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

Module 1

11 a. Explain the reversed Carnot refrigeration cycle with the help of T–s diagram and discuss the factors that limit its practical application in real refrigeration systems. (7 marks)

b. An air refrigeration system working on the Bell–Coleman cycle operates between 1 bar and 6 bar. The temperature of air at compressor inlet is 15°C and compression and expansion follow isentropic processes. Determine the temperature at the compressor outlet and turbine outlet. Assume $\gamma = 1.4$. (7 marks)

OR

12 a. Compare refrigerator and heat pump in terms of working principle, COP expressions and applications. (7 marks)

b. An air refrigeration system has a refrigeration capacity of 15 TR and operates with a COP of 2.5. Determine the power required to drive the compressor. (7 marks)

Module 2

13 a. Explain the vapour compression refrigeration cycle with the help of T–s and P–h diagrams, indicating the effect of superheating and subcooling on the cycle. (7 marks)

b. A vapour compression refrigeration system using R134a operates between evaporator temperature −10°C and condenser temperature 40°C. If the refrigerating effect is 150 kJ/kg and compressor work is 40 kJ/kg, determine the COP and refrigeration capacity for a mass flow rate of 0.05 kg/s. (7 marks)

OR

14 a. Explain the working principle of flash intercooling and flash gas removal in multi-stage vapour compression systems. (7 marks)

b. A refrigerator removes 12 TR of heat from the cold space and operates with a COP of 3. Determine the power input required and the heat rejected to the condenser. (7 marks)

Module 3

15 a. Explain the working principle of the Ammonia–Water vapour absorption refrigeration system with a neat schematic diagram and discuss the function of each component. (7 marks)

b. Compare vapour absorption and vapour compression refrigeration systems with respect to energy source, performance, applications and operating characteristics. (7 marks)

OR

16 a. Discuss the environmental impact of refrigerants with reference to ODP and GWP and explain the need for eco-friendly refrigerants. (7 marks)

b. Explain the criteria for selection of refrigerants for different refrigeration and air-conditioning applications. (7 marks)

Module 4

17 a. Discuss the historical development of cryogenic engineering and highlight the major milestones that contributed to modern cryogenic technology. (7 marks)

b. Explain the mechanical and thermal properties of engineering materials at cryogenic temperatures and their influence on design. (7 marks)

OR

18 a. Discuss the electrical and magnetic properties of materials at cryogenic temperatures. (7 marks)

b. Explain the major applications of cryogenic engineering in space technology, medicine, superconductivity and electronics. (7 marks)

Module 5

19 a. Explain the Linde–Hampson liquefaction system with a neat schematic diagram and discuss its operating principle. (7 marks)

b. Describe the Claude liquefaction system and explain how it improves the efficiency compared to the Linde system. (7 marks)

OR

20 a. Explain the liquefaction process of hydrogen and helium with special reference to ortho–para conversion in hydrogen liquefaction. (7 marks)

b. Discuss the critical components of liquefaction systems and explain how they influence the overall system performance. (7 marks)

B24ME4P46	HEAT TRANSFER EQUIPMENT DESIGN	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course provides a comprehensive understanding of the thermal design and performance analysis of various heat exchangers used in industrial applications. It begins with fundamental concepts such as classification, overall heat transfer coefficient, and effectiveness methods, followed by detailed design and analysis of double pipe and shell-and-tube heat exchangers using established methodologies. The course further explores cooling towers, emphasizing heat and mass transfer principles, performance evaluation, and design considerations. Advanced topics include industrial heat exchangers such as plate, regenerative, and compact heat exchangers, focusing on their construction, selection, and thermal design. Finally, the course introduces heat pipes, covering their working principles, design procedures, limitations, and emerging configurations, enabling students to apply engineering principles to analyze and design efficient thermal systems.

Prerequisites

Nil.

Course Outcomes

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

CO 1	Apply principles to design and analyze different types of heat exchangers, including double pipe heat exchangers. (Cognitive Level: Apply)
CO 2	Make use of design methodologies to evaluate shell and tube heat exchangers by calculating pressure drop, assessing fouling effects, and analyzing flow arrangements. (Cognitive Level: Apply)
CO 3	Apply engineering concepts to design and analyze the performance of cooling towers. (Cognitive Level: Apply)
CO 4	Develop designs for plate heat exchangers, regenerators, and compact recuperative heat exchangers. (Cognitive Level: Apply)
CO 5	Utilize knowledge to design heat pipes for various applications. (Cognitive 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		1	1				1
CO 2	3	2	2	1		1	1				1
CO 3	3	2	2	1		1	1				1
CO 4	3	2	2	1		1	1				1
CO 5	3	2	2	1		1	1				1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	10	10	10
Understand	30	30	30
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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Thermal performance analysis of heat exchangers (7 hours)

Classification of heat exchangers, Overall heat transfer coefficient, Controlling film coefficient, Temperature effectiveness, LMTD, Effectiveness of heat exchanger, Double pipe heat exchangers, Caloric or average fluid temperature, Pipe-wall temperature, Film coefficients for tubes and annuli, Equivalent diameter

Fouling factors, Double pipe exchangers in series-parallel arrangements, Design calculation of double pipe heat exchanger.

MODULE 2: Shell and tube heat exchangers (7 hours)

Classification of shell and tube exchangers, Tube layouts, Baffle spacing, Design calculation of shell and tube heat exchangers, Shell-side film coefficients, Shell-side equivalent diameter, True temperature difference in a 1-2 heat exchanger, Performance analysis of 1-2 heat exchangers, Kerns method, Bell-Delaware method, Flow arrangements for increased heat recovery.

MODULE 3: Cooling towers (7 hours)

Classification of cooling towers, Wet bulb and dew point temperatures, Lewis number, Diffusion theory, Cooling tower internals, Heat balance, Heat transfer by simultaneous diffusion and convection, Design and analysis of cooling towers, Determination of number of diffusion units, Performance evaluation of cooling towers, Influence of process conditions and operating variables on their design.

MODULE 4: Industrial heat Exchangers (7 hours)

Construction and thermal features of plate heat exchangers, Analysis, Rating and sizing of plate heat exchangers, Stationary regenerators, Rotary regenerators, Thermal design of regenerators, Influence of matrix material, size and arrangement, Classification and selection of compact heat exchangers, Design of plate fin heat exchangers, Design of tube fin heat exchangers.

MODULE 5: Heat pipes (8 hours)

Types and applications, Working principle, Fluid selection, Wick selection, Material selection, Preliminary design considerations, Heat pipe design procedure, Determination of heat pipe diameter, Design of heat pipe containers, Wick design, Entrainment and boiling limits, Design problems, Non-conventional heat pipes – Flat, Rotating, Reciprocating and Disc shaped heat pipes, Micro and Mini heat pipes.

Text Books

1. Kern D.Q., *Process Heat Transfer,* Tata McGraw-Hill.
2. Sarit K. Das, *Process Heat Transfer*, Narosa Publishing House.
3. Dunn P.D. and Reay D.A., *Heat pipes*, Pergamon Press.
4. Fraas A.P., *Heat Exchanger Design*, John Wiley & Sons.
5. Chi S.W., *Heat Pipe Theory and Practice - A Source Book*, McGraw Hill.

Reference Books

1. Kakac S. and Liu H., *Heat Exchangers: Selection, Rating and Thermal Design*, CRC Press.
2. J.E. Hesselgreaves, *Compact Heat Exchangers*, Pergamon.
3. R.K. Shah, Dusan P. Sekulic, *Fundamentals of Heat Exchanger Design*, John Wiley & Sons.
4. Kuppan Thulukkanam, *Heat Exchanger Design Handbook*, CRC Press.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Classification of heat exchangers, Overall heat transfer coefficient, Controlling film coefficient, Temperature effectiveness, LMTD, Effectiveness of heat exchanger.	2
1.2	Double pipe heat exchangers, Caloric or average fluid temperature, Pipe-wall temperature.	1
1.3	Film coefficients for tubes and annuli, Equivalent diameter, Fouling factors.	2
1.4	Double pipe exchangers in series-parallel arrangements, Design calculation of double pipe heat exchanger.	2
	Module 2	**7**
2.1	Classification of shell and tube exchangers, Tube layouts, Baffle spacing, Design calculation of shell and tube heat exchangers.	2
2.2	Shell-side film coefficients, Shell-side equivalent diameter.	1
2.3	True temperature difference in a 1-2 heat exchanger, Performance analysis of 1-2 heat exchangers.	1
2.4	Kerns method, Bell-Delaware method.	2
2.5	Flow arrangements for increased heat recovery.	1
	Module 3	**7**
3.1	Classification of cooling towers, Wet bulb and dew point temperatures.	1
3.2	Lewis number, Diffusion theory, Cooling tower internals.	1
3.3	Heat balance, Heat transfer by simultaneous diffusion and convection.	2
3.4	Design and analysis of cooling towers, Determination of number of diffusion units.	2
3.5	Performance evaluation of cooling towers, Influence of process conditions and operating variables on their design.	1
	Module 4	**7**
4.1	Construction and thermal features of plate heat exchangers, Analysis, Rating and sizing of plate heat exchangers.	2
4.2	Stationary regenerators, Rotary regenerators, Thermal design of regenerators.	2

4.3	Influence of matrix material, size and arrangement, Classification and selection of compact heat exchangers.	1
4.4	Design of plate fin heat exchangers.	1
4.5	Design of tube fin heat exchangers.	1
	Module 5	**8**
5.1	Types and applications, Working principle, Fluid selection, Wick selection, Material selection.	2
5.2	Preliminary design considerations, Heat pipe design procedure, Determination of heat pipe diameter.	2
5.3	Design of heat pipe containers, Wick design, Entrainment and boiling limits, Design problems.	2
5.4	Non-conventional heat pipes – Flat, Rotating, Reciprocating and Disc shaped heat pipes.	1
5.5	Micro and Mini heat pipes.	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the major classifications of heat exchangers.
2. Explain the significance of average fluid temperature and pipe wall temperature.
3. Analyse the true temperature difference for series – parallel arrangements in double pipe heat exchangers.

Course Outcome 2 (CO2):

1 Explain the significance of tube layout in shell and tube heat exchangers.

2 Explain the significance of true temperature difference in 1-2 heat exchangers.

3 Explain the flow arrangements for increased heat recovery.

Course Outcome 3 (CO3):

1. Explain the classification of cooling towers.
2. Explain diffusion theory.
3. Explain the role of fill in cooling towers.

Course Outcome 4 (CO4):

1. Explain a gasketed plate heat exchanger.
2. Explain the advantages and limitations of compact heat exchangers.
3. Explain the different types of regenerators.

Course Outcome 5 (CO5)

1. Explain the working principle of heat pipe.
2. Explain the different types of heat pipe.
3. Explain the working of a disc shaped heat pipe.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24MEP46**

Course Name: **HEAT TRANSFER EQUIPMENT DESIGN**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Describe the classifications of heat exchangers.

2 Discuss fouling in heat exchangers.

3 Explain the function of baffles in shell and tube heat exchangers.

4 Outline the factors contributing to pressure drop in shell and tube heat exchangers.

5 Explain the significance of the Lewis number.

6 Discuss the principles of diffusion theory.

7 Highlight the advantages of plate heat exchangers.

8 Evaluate the advantages and limitations of compact heat exchangers.

9 List the applications of heat pipes.

10 Describe the working principle of a heat pipe.

PART B

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

Module 1

11 A counter flow double pipe heat exchanger is to heat water from $20^{O}C$ to $80^{O}C$ at a rate of 1.2 kg/s. The heating is to be accomplished by geothermal water available at $160^{O}C$ at a mass flow rate of 2 kg/s. The overall heat transfer coefficient of the heat exchanger is 640 W/m^2K. The specific heats of water and the geothermal fluid are 4.18 kJ/kg-K and 4.31 kJ/kg-K respectively. Determine the heat transfer surface area of the exchanger 14 marks)

OR

12 Exhaust gases of specific heat 1.1 kJ/kg-K flowing through a double pipe parallel flow heat exchanger at the rate of 0.28 kg/s is cooled from 450^{O}C to170^{O}C. The cooling is done by water with specific heat 4.18 kJ/kg-K entering the unit at 0.45 kg/s and 15^{O}C. The overall heat transfer coefficient of the exchanger is 142 W/m^{2}K. Determine the surface area of the heat exchanger. (14 marks)

Module 2

13 A single pass shell and tube heat exchanger in which water at 70^{O}C transfers heat to a service fluid at 80^{O}C. The mass flow rate of water and the service fluid are 2 kg/s and 3 kg/s respectively. The shell length is 8 m and the number of tubes are30. The overall heat transfer coefficient is 1200 W/m^{2}K. Determine the tube diameter if the effectiveness is 0.85. Specific heat of service fluid is 2.9 kJ/kg-K. (14marks)

OR

14 A shell and tube heat exchanger has steel pipes of 32 mm outer diameter and 26 mm inner diameter. Ethylene glycol flows in tubes having a heat transfer coefficient of 1680 W/m^{2}K and a fouling resistance of 0.00065 m^{2}K/W. Water flows on shell side having a heat transfer coefficient of 3215 W/m^{2}K and a fouling resistance of 0.0003 m^{2}K/W. The thermal conductivity of the tube 68 W/m-K. Determine the overall heat transfer coefficient of the heat exchanger. (14 marks)

Module 3

15 Determine the amount of air to be handled and quantity of make up water required by a cooling tower when 100 kg/min of water is cooled from 37^{O}C to 32^{O}C. Atmospheric conditions are 35^{O}C DBT and 24^{O}C WBT. Assume that the air leaves the tower 90% saturated and 32^{O}C WBT. Assume that there is no entrainment loss. (14 marks)

OR

16 Atmospheric air enters the adiabatic saturation chamber with 31^{O}C DBT and 20^{O}C WBT. Determine a) humidity ratio b) vapour pressure and c) relative humidity. (14 marks)

Module 4

17 A counter current flow plate heat exchanger with 194 plates is required to heat 5 kg/s of water from 15^{O}C to 90^{O}C using 10 kg/s of hot water with an inlet temperature of 95^{O}C. The plates are 1 m high and 0.25 m wide with a gap of 5mm. Determine the pressure drop of the hot stream. Take properties of water at 55^{O}C. (14 marks)

OR

18 Explain the influence of matrix material and size in the design of regenerators. (14 marks)

Module 5

19 Explain the criteria for fluid selection, wick selection and material selection in heat pipe design. (14 marks)

OR

20 Explain the working of a reciprocating heat pipe with figure. (14 marks)

B24ME4P47	ADVANCED NON DESTRUCTIVE TESTING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces modern NDT methods and advanced inspection technologies used for quality assurance and structural health monitoring. The course focuses on the principles, instrumentation, testing procedures, advantages, and limitations of advanced techniques such as ultrasonic testing, radiographic testing, eddy current testing, acoustic emission testing, infrared thermography, and other emerging inspection methods. Emphasis is placed on understanding defect detection mechanisms, signal interpretation, standards and codes, and the selection of appropriate NDT methods for different materials and engineering applications. The course also highlights industrial practices and the role of NDT in preventive maintenance, failure analysis, and life assessment of critical components.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the fundamentals and importance of non-destructive testing methods. (Cognitive Knowledge Level: Understand)
CO 2	Apply appropriate surface inspection techniques for defect identification. (Cognitive Knowledge Level: Apply)
CO 3	Apply ultrasonic testing methods for defect detection. (Cognitive Knowledge Level: Apply)
CO 4	Apply radiographic and electromagnetic testing techniques for evaluation of materials. (Cognitive Knowledge Level: Apply)
CO 5	Understand the advanced NDT methods and their industrial applications (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	–	–	–	–	–	1
CO 2	2	3	–	2	3	–	–	–	–	–	–
CO 3	2	3	–	2	3	–	–	–	–	–	–
CO 4	2	3	–	2	3	1	1	–	–	–	–
CO 5	2	2	1	–	2	1	–	–	–	–	2

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	20	20
Understand	40	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Fundamentals of Non-Destructive Testing (6 hours)

Introduction to Non-Destructive Testing – Importance and advantages – Comparison with destructive testing – Applications of NDT in manufacturing, aerospace, nuclear and structural industries- Types of discontinuities in materials – Surface and subsurface defects – Causes of defects in casting, welding and forging. Overview and classification of NDT methods – Visual testing – Selection of appropriate NDT techniques – Codes and standards for inspection.

Module 2: Surface Inspection Methods (7 hours)

Liquid Penetrant Testing (LPT) – Principle, types of penetrants, inspection procedure, advantages, limitations and applications -Magnetic Particle Inspection (MPI) – Principle, magnetization techniques, types of magnetic particles, inspection procedure and applications - Visual Inspection (VT) – Direct and remote visual inspection – Optical aids – Bore scopes and video scopes – Applications in industrial inspection.

Module 3: Ultrasonic Testing (7 hours)

Principle of ultrasonic testing – Ultrasonic wave generation and propagation – Types of waves – Pulse echo method- Ultrasonic testing equipment – Transducers – Couplants – Display methods (A-scan, B-scan, C-scan) -Defect detection and thickness measurement – Angle beam testing – Immersion testing – Applications in weld inspection and material evaluation.

Module 4: Radiographic and Electromagnetic Methods (8 hours)

Radiographic Testing (RT) – Principles of X-ray and gamma ray radiography – Equipment – Film and digital radiography – Radiographic image interpretation - Radiation safety measures – Advantages and limitations of radiographic inspection - Eddy Current Testing (ECT) – Principle, probe types, signal interpretation and applications in crack detection and coating thickness measurement.

Module 5: Advanced and Emerging NDT Techniques (8 hours)

Acoustic Emission Testing (AET) – Principle and applications - Infrared Thermography – Thermal imaging principles – Active and passive thermography - Laser based inspection techniques – Holography and shearography -Structural Health Monitoring (SHM) – Sensors and data acquisition – Applications in aerospace, pipelines and civil structures - Automation and digital NDT systems – Introduction to intelligent inspection systems.

Text Books

1. Baldev Raj, T. Jayakumar, M. Thavasimuthu – *Practical Non-Destructive Testing*, Narosa Publishing House
2. Paul E. Mix – *Introduction to Non-Destructive Testing: A Training Guide*., John Wiley & Sons.

Reference Books

1. Charles J. Hellier – *Handbook of Non-Destructive Evaluation*., McGraw-Hill Education.
2. Xavier Maldague – *Theory and Practice of Infrared Technology for NDT*., John Wiley & Sons.
3. American Society for Nondestructive Testing – *NDT Handbook Series*.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**6**
1.1	Introduction to Non-Destructive Testing, Importance and advantages – Comparison with destructive testing – Applications of NDT in various industries.	2
1.2	Types of discontinuities in materials – Surface and subsurface defects – Causes of defects in casting, welding and forging.	2
1.3	Overview & classification of NDT methods, visual testing, selection of appropriate techniques, codes/standards for inspection.	2
	Module 2	**7**
2.1	Liquid Penetrant Testing (LPT) – Principle, types of penetrants, inspection procedure, advantages, limitations and applications	2
2.2	Magnetic Particle Inspection– Principle, magnetization techniques, types of magnetic particles, inspection procedure and applications.	2
2.3	Visual Inspection (VT) – Direct and remote visual inspection	1
2.4	Optical aids – Bore scopes and video scopes – Applications in industrial inspection.	2
	Module 3	**7**
3.1	Principle of ultrasonic testing – Ultrasonic wave generation and propagation – Types of waves – Pulse echo method.	2
3.2	Ultrasonic testing equipment – Transducers – Couplants – Display methods (A-scan, B-scan, C-scan).	2
3.3	Defect detection and thickness measurement – Angle beam testing – Immersion testing	2
3.4	Applications in weld inspection and material evaluation.	1
	Module 4	**8**
4.1	Radiographic Testing – Principles of X-ray and gamma ray radiography	2
4.2	Equipment – Film and digital radiography – Radiographic image interpretation	2
4.3	Radiation safety measures – Advantages and limitations of radiographic inspection	1
4.4	Eddy Current Testing (ECT) – Principle, probe types	2
4.5	signal interpretation and applications in crack detection and coating thickness measurement	1
	Module 5	**8**
5.1	Acoustic Emission Testing (AET) – Principle and applications.	2
5.2	Infrared Thermography – Thermal imaging principles – Active and passive thermography	2
5.3	Laser based inspection techniques – Holography and shearography.	1
5.4	Structural Health Monitoring (SHM) – Sensors and data acquisition	1
5.5	Applications in aerospace, pipelines and civil structures	1
5.6	Automation and digital NDT systems – Introduction to intelligent inspection systems	1
	Total	**36 Hours**

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4P47**

Course Name: **ADVANCED NON-DESTRUCTIVE TESTING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Compare destructive testing vs. non-destructive testing

2 List the advantages and applications of visual testing

3 Write short notes about types of penetrants used in LPI

4 Explain about different types of particles used in MPI

5 List the types of waves used in ultrasonic testing

6 Write short notes about the advantages and disadvantages of ultrasonic testing

7 Write short notes about radiographic image interpretation

8 Explain about signal interpretation in ECT

9 Write short notes about thermal imaging principles

10 Explain the significance of intelligent inspection systems

PART B

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

Module 1

11 With suitable examples detail about surface and subsurface defects happening during casting process. (14 Marks)

OR

12 Explain in detail about different codes and standards of NDT inspection. (14 Marks)

Module 2

13 With neat sketches explain the liquid penetrant testing technique. (14 Marks)

OR

14 With the help of labelled diagrams explain different magnetization techniques in magnetic particle testing. (14 Marks)

Module 3

15 With the help of neat diagrams explain the working principle of ultrasonic testing. (14 Marks)

OR

16 Differentiate between A – scan, B – scan and C –scan in ultrasonic testing method. (14 Marks)

Module 4

17 Explain the working principle of X – ray radiography. (14 Marks)

OR

18 With the help of neat sketches, explain the working of eddy current testing. List the advantages, disadvantages and applications of the method (14 Marks)

Module 5

19 Explain about different types of laser-based inspection techniques (14 Marks)

OR

20 Explain about the significance of intelligent inspection systems (14 Marks)

B24ME4P48	MEMS AND NANOTECHNOLOGY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The miniaturization of mechanical systems and the engineering of materials at the atomic scale are driving the next industrial revolution. This course, MEMS and Nanotechnology, provides a comprehensive introduction to the design, fabrication, and application of Micro-Electro-Mechanical Systems (MEMS) and nanomaterials. As traditional manufacturing reaches its physical limits, engineers must understand the unique scaling laws and non-conventional fabrication techniques required for high-precision sensors, actuators, and nanostructured components used in aerospace, medical, and electronics industries.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the fundamental scaling laws, materials, and working principles of MEMS sensors and actuators. (Cognitive Knowledge Level: Understand)
CO 2	Apply micro-fabrication processes such as photolithography, etching, and thin-film deposition. (Cognitive Knowledge Level: Apply))
CO 3	Differentiate between top-down and bottom-up synthesis methods of nanomaterials. (Cognitive Knowledge Level: Understand)
CO 4	Outline the characterization techniques for nanomaterials such as SEM, TEM, and AFM. (Cognitive Knowledge Level: Understand)
CO 5	Explain human, environmental, and sustainability aspects influencing responsible technology deployment and management. (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
CO 2	3		2		2						
CO 3	2	2									
CO 4	3			3	2						
CO 5	2		3			2	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Introduction to MEMS (7 Hours)

History and evolution of MEMS. Scaling laws in miniaturization: scaling in geometry, electrostatics, and electromagnetics. Materials for MEMS: Silicon as a substrate, polymers, and piezoelectric materials. Principles of microsensors and microactuators: electrostatic, thermal, and piezoresistive sensing

Module 2: Micro-fabrication Techniques (7 Hours)

Cleanroom requirements and levels. Photolithography: mask generation and exposure. Thin-film deposition: Chemical Vapor Deposition (CVD) and Physical Vapor Deposition (PVD). Etching processes: Wet vs. Dry etching, Isotropic vs. Anisotropic etching. Bulk and surface micromachining.

Module 3: Nanomaterials Synthesis (8 Hours)

Introduction to nanotechnology and the nanoscale. Synthesis of nanomaterials: Top-down approaches (mechanical alloying, milling) and Bottom-up approaches (Sol-gel, CVD, molecular beam epitaxy). Carbon nanotubes (CNTs) and Graphene: structure, properties, and production methods

Module 4: Characterization of Nanomaterials (7 Hours)

Fundamental principles and theory of advanced microscopy. Electron Microscopy: Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM). Scanning Probe Microscopy: Atomic Force Microscopy (AFM) and Scanning Tunneling Microscopy (STM). X-ray diffraction (XRD) for particle size determination.

Module 5: Applications and Future Trends (7 Hours)

MEMS in automotive (airbags, pressure sensors) and biomedical (Bio-MEMS). Nanotechnology in energy storage and conversion: solar cells and fuel cells. Nanocoatings for wear and corrosion resistance. Environmental and safety impacts of nanomaterials.

Textbooks

1. Tai-Ran Hsu, *MEMS and Microsystems: Design and Manufacture*, Tata McGraw Hill.
2. Madou M. J., *Fundamentals of Microfabrication*, CRC Press.

References

1. Bharat Bhushan, *Springer Handbook of Nanotechnology*, Springer.
2. N. Taniguchi, *Nanotechnology*, Oxford University Press.
3. S. D. Senturia, *Microsystem Design*, Kluwer Academic Publishers.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	History, evolution, and milestones of MEMS technology.	1
1.2	Scaling laws: Scaling in geometry and rigid body dynamics.	1
1.3	Scaling in electrostatic and electromagnetic forces.	1
1.4	Silicon as a substrate: Piezoresistivity and mechanical properties.	1
1.5	MEMS Materials: Polymers, Ceramics, and Piezoelectric materials.	1
1.6	Working principles of electrostatic and thermal microsensors.	1
1.7	Microactuators: Principles and industrial applications.	1
	Module 2	**7**
2.1	Cleanroom environment: Standards and contamination control.	1
2.2	Photolithography: Masking, exposure, and development stages.	1
2.3	Thin-film deposition: Chemical Vapor Deposition (CVD).	1
2.4	Physical Vapor Deposition (PVD): Sputtering and Evaporation.	1
2.5	Wet etching vs. Dry etching: Selectivity and directionality.	1
2.6	Bulk micromachining: Isotropic and Anisotropic etching.	1
2.7	Surface micromachining and LIGA process.	1
	Module 3	**8**
3.1	Introduction to the Nanoscale: Surface-to-volume ratio effects.	1
3.2	Top-down synthesis: High-energy ball milling and lithography.	2
3.3	Bottom-up synthesis: Sol-gel processing and self-assembly.	1
3.4	Chemical Vapor Deposition (CVD) for nanotube growth	1
3.5	Carbon Nanotubes (CNTs): Single-walled and multi-walled.	1
3.6	Graphene: Properties, structure, and synthesis methods.	1
3.7	Quantum dots and Nanocomposites: An overview.	1
	Module 4	**7**
4.1	Interaction of electrons with matter: Theory of microscopy.	1
4.2	Scanning Electron Microscopy (SEM): Principle and instrumentation.	1
4.3	Transmission Electron Microscopy (TEM): High-resolution imaging.	1
4.4	Atomic Force Microscopy (AFM): Contact and non-contact modes.	1
4.5	Scanning Tunneling Microscopy (STM): Principle and operation.	1
4.6	X-Ray Diffraction (XRD) for crystal structure analysis.	2
	Module 5	**7**
5.1	Automotive applications: Airbag sensors and manifold pressure.	1
5.2	Biomedical MEMS (Bio-MEMS): Lab-on-a-chip and drug delivery.	2
5.3	Nanotechnology in energy: Nano-structured solar cells.	2
5.4	Nano-coatings for mechanical wear and thermal protection.	1
5.5	Environmental impact and safety regulations of nanomaterials.	1
	Total	**36 Hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. llustrate the scaling effects on the surface-to-volume ratio and explain how it influences the behavior of micro-scale mechanical systems.
2. Explain the working principle of a capacitive-type MEMS accelerometer used in automotive airbag systems.

Course Outcome 2 (CO2):

1. Describe the various stages of the photolithography process, highlighting the role of positive and negative photoresists.
2. Compare bulk micromachining and surface micromachining techniques based on material removal and design flexibility.

Course Outcome 3 (CO3):

1. Contrast the "Top-down" and "Bottom-up" synthesis approaches for nanomaterials using specific examples like ball milling and CVD.
2. Explain the chemical vapor deposition (CVD) process for the growth of single-walled carbon nanotubes (CNTs).

Course Outcome 4 (CO4):

1. Describe the principle of operation and the primary components (electron gun, lenses, and detectors) of a Scanning Electron Microscope (SEM).
2. Compare the imaging mechanisms of Atomic Force Microscopy (AFM) and Scanning Tunneling Microscopy (STM).

Course Outcome 5 (CO5)

1. Illustrate the operation of a "Lab-on-a-chip" Bio-MEMS device and discuss its advantages for medical diagnostics.
2. Select and justify the use of specific nanocoatings to improve the wear resistance and thermal stability of turbine blades

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4P48**

Course Name: **MEMS AND NANOTECHNOLOGY**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define the term "Scaling Law" in MEMS.
2. Why is silicon the preferred substrate for MEMS?
3. Differentiate between dry and wet etching.
4. What is the role of a photoresist in lithography?
5. Define "Bottom-up" synthesis.
6. List two unique properties of Carbon Nanotubes.
7. State the principle of Atomic Force Microscopy (AFM).
8. Mention the use of X-ray diffraction in nanotechnology.
9. What are Bio-MEMS? Give an example.
10. Name two hazards associated with nanoparticle exposure

PART B

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

Module 1

11. (a) Explain the scaling effects on electrostatics and fluid mechanics as systems get smaller. (10 marks)

    (b) Describe the working of a piezoresistive micro-pressure sensor. (4 marks)

OR

12. (a) With a neat sketch, explain the working principle of a Piezoresistive Pressure Sensor. (7 marks)

    (b) Describe the different types of materials used in MEMS beyond silicon, such as polymers and ceramics. (7 marks)

Module 2

13. (a) Explain the Photolithography process in detail. Describe the specific roles of the mask, UV light source, and developer solution. (10 marks)

    (b) Define the "Selectivity" and "Aspect Ratio" parameters in the context of micro-etching. (4 marks)

OR

14. (a) Compare Bulk Micromachining and Surface Micromachining. Use diagrams to show how a cantilever beam is fabricated using both methods. (7 marks)

    (b) Discuss the LIGA process and explain why it is used for producing high-aspect-ratio microstructures. (7 marks)

Module 3

15. (a) Describe the "Bottom-up" synthesis of nanomaterials. Explain the Sol-Gel process and its various stages with a flow chart. (9 marks)

    (b) Explain the structure and chirality of Single-Walled Carbon Nanotubes (SWCNTs). (5 marks)

OR

16. (a) Explain the principle of Chemical Vapor Deposition (CVD) for the production of Graphene. Discuss the role of the metal catalyst and precursor gas. (9 marks)

    (b) Compare the properties of Graphene with traditional structural materials used in Mechanical Engineering. (5 marks)

Module 4

17. (a) Explain the principle and theory of Scanning Electron Microscopy (SEM). Describe the major components of the equipment including the electron gun and detectors. (10 marks)

    (b) Distinguish between the imaging techniques of Atomic Force Microscopy (AFM) in contact vs. non-contact modes. (4 marks)

OR

18. (a) Define the principle of Transmission Electron Microscopy (TEM). Explain how electron diffraction is used to study the crystal structure of nanoparticles. (7 marks)

    (b) Compare Scanning Tunneling Microscopy (STM) and AFM. Under what conditions is STM preferred for atomic-level imaging? (7 marks)

Module 5

19. (a) Describe the application of MEMS in the automotive industry. Focus on the system components and operation of an Airbag Accelerometer. (10 marks)

    (b) Explain the concept of "Lab-on-a-chip" and its advantages for rapid medical diagnostics. (4 marks)

OR

20. (a) Discuss the use of Nanotechnology in energy storage. Explain how nanostructured electrodes improve the efficiency of Lithium-ion batteries or Fuel Cells. (8 marks)

    (b) Explain the sequential steps involved in applying Nanocoatings for thermal barrier applications in turbine blades. (6 marks)

B24ME4P49	ADVANCED NUMERICALLY CONTROLLED MACHINING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course is designed to provide learners with a strong foundation in modern computer-controlled manufacturing systems. It begins with basic concepts of CNC technology and progressively develops knowledge of machine construction, tooling, setup, and operation. Emphasis is placed on practical problem solving and manual programming for 3-axis CNC milling machines and CNC lathes, aligning with current industrial practices. The syllabus integrates numerical exercises and programming tasks to strengthen understanding of coordinate systems, machining cycles, and process planning. In addition, the course introduces advanced manufacturing systems such as 5-axis CNC milling machines and turn-mill centers at a theoretical level to create awareness of emerging technologies. Safety, accuracy, and productivity considerations are highlighted throughout the course. By the end of the program, learners will be prepared to interpret engineering drawings, plan machining operations, and adapt to advanced CNC environments in industry.

Prerequisites

Nil

Course Outcomes

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

CO 1	Identify the basic concepts, terminology, and classification of CNC machines, including CNC milling machines and CNC lathes. (Cognitive Knowledge Level: Understand)
CO 2	Explain the construction, working principles, control systems, and interpolators used in CNC milling machines and CNC lathes. (Cognitive Knowledge Level:Understand)
CO 3	Choose the coordinate systems, machine offsets and machining cycles used in CNC milling and turning, and develop a process plan for the machining. (Cognitive Knowledge Level: Apply)
CO 4	Apply concepts of NC machine tools to solve numerical problems for 3-axis CNC milling machines. (Cognitive Knowledge Level: Apply)
CO 5	Understand the usage of various tool materials, tool geometry and work holding and tool holding devices used in NC machine tools. (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	–	–	–	–	–	1
CO 2	3	2	–	–	2	–	–	–	–	–	1
CO 3	3	3	3	2	3	–	–	–	–	1	–
CO 4	3	3	2	2	3	–	–	–	–	–	–
CO 5	2	2	1	–	2	–	–	–	–	–	1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	10	20
Understand	60	30	40
Apply	-	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Numerical Control Systems and CNC Machine Structures (6 hours)

Evolution of manufacturing: Conventional machining -Numerical Control (NC) -Computer Numerical Control (CNC). Numerical Control (NC) systems: definition, basic elements of NC systems, advantages and disadvantages of NC systems, applications of NC systems. Direct Numerical Control (DNC): concept, need, advantages, and applications. Structure of NC machines. Machine Control Unit (MCU): functions of MCU, structure of MCU – input unit, memory unit, control logic unit, data processing unit, output and drive unit. Different MCUs used in NC machines. CNC machining centres: vertical axis machining centres, horizontal axis machining centres. CNC turning centres: multi-axis turning centres, vertical turning centres, introduction to turn-mill centres.

MODULE 2: CNC Control Systems and Interpolation Techniques (7 hours)

Types of control systems used in CNC machines: open-loop control system, closed-loop control system, comparison of open-loop and closed-loop systems. Motion control methods in NC systems: Point-to-Point (PTP) systems, Contouring systems. Adaptive control systems: concept and applications. Feedback devices used in CNC machines: absolute encoders, incremental encoders, tachometers. Interpolation in NC machines: role of interpolators in MCU, Digital Differential Analyzer (DDA) integrator. Types of interpolation: linear interpolation, circular interpolation.

MODULE 3: Axis Systems, NC Programming Concepts, and Machine Setup (7 hours)

Axis systems in NC machines: Cartesian coordinate system, axis designation and direction conventions, right-hand rule, Linear axes and rotary axes. Incremental and absolute programming in NC systems: concept, advantages and limitations, comparison between absolute and incremental programming. Machine setup and offsets: machine zero and homing, work coordinate systems, tool length offset (milling), tool nose radius offset (lathe), datum setting and referencing. Touch trigger probes: working principle and applications. Process planning: steps in process planning, selection of machining sequence. Process parameters of milling, drilling, and turning operations. Introduction to post-processing (concept only).

MODULE 4: CNC Part Programming, Parametric Programming, and CAM (8 hours)

CNC part program: structure of an NC part program. Functions used in CNC programming: preparatory functions, miscellaneous functions, symbols used in CNC programming, tool functions, spindle speed and feed functions. Compensation techniques: cutter radius compensation, tool nose radius compensation, tool length compensation, work offsets. Startup blocks in NC programs, Canned cycles used in CNC machines. Subroutines and subprograms. Parametric programming (FANUC controller only): variables, functions, logical operators, conditional expressions, loops. Part programming of 3-axis CNC milling machines: straight cutting, contour cutting, drilling (simple geometries only). Introduction to Computer Aided Manufacturing (CAM): Concept of CAM, need for CAM in modern manufacturing. CAM software practice.

MODULE 5: CNC Turning Operations and Tooling Systems (8 hours)

Diameter and radius programming in CNC lathes. Lathe cycles: straight turning, facing, and profile cutting cycles, constant Surface Speed (CSS) in turning. Part programming in CNC

lathe (simple geometries only). CNC tooling: tool materials and applications of various cutting tool materials. Turning tool geometry. ISO coding system for inserts used in turning operations. Tool holders for milling operations. Tool presetting systems. Machining centre automation systems: automatic tool changers (ATC), pallets. Work holding devices used in CNC milling machines.

Text Books

1. Yoram Koren, *Computer Control of Manufacturing Systems*: McGraw Hill Education India Private Limited.
2. P N Rao, *CAD/CAM Principles and Applications,* McGraw Hill Education India Private Limited.
3. M. P. Groover, *Automation, Production Systems, and Computer-Integrated Manufacturing*. Pearson Education.
4. Chris McMahon, *CAD/CAM Principles, Practice and Manufacturing Management*, Addison-Wesley

Reference Books

1. Peter Smid, *CNC Programming Handbook*, Industrial Press.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	MODULE 1	**6**
1.1	Evolution of manufacturing: Conventional → NC → CNC	1
1.2	NC systems: definition and basic elements	1
1.3	Advantages, disadvantages and applications of NC systems	1
1.4	DNC: concept and applications	1
1.5	Structure of NC machines and MCU (functions & structure)	1
1.6	Types of MCU, CNC machining centres & CNC turning centres	1
	MODULE 2	**7**
2.1	Open-loop and closed-loop control systems	1
2.2	Adaptive control systems and feedback devices	1
2.3	Motion control methods: PTP systems, contouring systems	1
2.4	Feedback devices used in CNC machines	1
2.5	Interpolators and DDA integrator	1
2.6	Linear interpolation	1
2.7	Circular interpolation	1
	MODULE 3	**7**
3.1	Cartesian coordinate system and axis designation	1
3.2	Linear axes and rotary axes in CNC machines	1
3.3	Absolute programming	1
3.4	Incremental programming and comparison	1
3.5	Machine zero, homing and work coordinate systems	1

3.6	Tool offsets and datum setting	1
3.7	Process planning and post-processing (introductory)	1
	MODULE 4	**8**
4.1	Structure of NC part program	1
4.2	G-codes, M-codes, symbols, speed & feed functions	2
4.3	Compensation techniques and startup blocks	1
4.4	Canned cycles and subprograms	1
4.5	Parametric programming (FANUC: variables, loops, logic)	1
4.6	3-axis milling programming (straight & contour cutting)	1
4.7	Introduction to CAM and CAM workflow. CAM software practice.	1
	MODULE 5	**8**
5.1	Diameter and radius programming in lathes	2
5.2	Lathe cycles: straight turning and facing	1
5.3	Profile cutting cycles and CSS	1
5.4	CNC lathe part programming (simple geometries)	2
5.5	Tool materials and applications	1
5.6	Tool geometry, ISO insert coding, ATC & workholding	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Compare a conventional machine tool with NC machine tool
2. Explain the features of DNC
3. Explain the structure of a NC machine tool

Course Outcome 2 (CO2):

1. Explain the types of control systems used in NC machine tools
2. Explain different types of encoders used in NC machine tools
3. Explain various motion control systems used in NC machines

Course Outcome 3 (CO3):

1. Explain the co-ordinate system used in NC milling machine and turning machine
2. Compare incremental and absolute systems used in NC systems
3. Explain process planning in machining

Course Outcome 4 (CO4):

1. Explain the structure of a NC part program
2. Explain the importance of cutter radius compensation in NC machine tools
3. Explain the use of canned cycles in NC part programming

Course Outcome 5 (CO5)

1. Explain various types of lathe cycles

2. Explain the ISO coding for tungsten carbide inserts used in turning
3. Explain various work holding devices used in NC milling machine.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4P49**

Course Name: **ADVANCED NUMERICALLY CONTROLLED MACHINING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1	Differentiate between Vertical Machining Centre (VMC) and Horizontal Machining Centre (HMC).
2	Explain the concept of Direct Numerical Control (DNC)
3	Define Point-to-Point (PTP) control and contour control.
4	What is interpolation in NC machines?
5	Explain the Cartesian coordinate system used in CNC machines.
6	Compare absolute programming and incremental programming
7	Write the general structure of an NC part program.
8	What are canned cycles? Mention any two commonly used canned cycles.
9	Explain straight turning cycle and facing cycle in CNC lathe.
10	What are Automatic Tool Changers (ATC)? Mention their purpose.

PART B

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

Module 1

11	Describe the structure of an NC machine tool. Explain the functions and internal structure of the Machine Control Unit (MCU) with neat diagrams. (14 marks)

OR

12	Compare the advantages and limitations of NC machine tools and conventional machine tools (14 marks)

Module 2

13	Explain open-loop and closed-loop control systems used in CNC machines with neat block diagrams. Compare their advantages and limitations. (14 marks)

OR

14 Explain the role of feedback devices in CNC machines. Describe the working of absolute encoders, incremental encoders, and tachometers. (14 marks)

Module 3

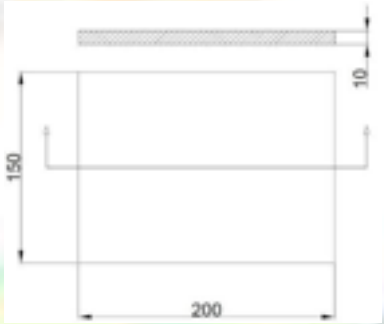
15 Explain the concept and working principle of touch trigger probes used in CNC machines. Discuss their applications in part setup and inspection. (14 marks)

OR

16 Discuss the steps involved in process planning for CNC machining. Explain how machining sequence, cutting parameters, and tool selection influence productivity and surface finish. (14 marks)

Module 4

17 Prepare a CNC part program to produce the part shown in Figure from a steel block of size 205 mm x 155 mm x 10 mm. The maximum permissible cutting speed is 90 m/min and the maximum feed rate is 0.18 mm/tooth. Use a square end mill of 16 mm diameter with 4 flutes as the tool. (14 marks)

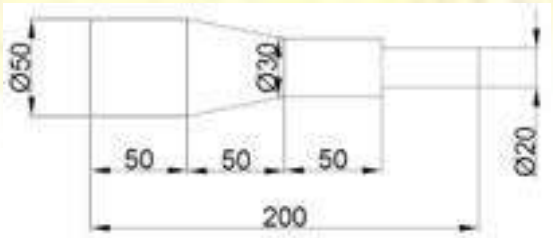


OR

18 Explain machine zero, work coordinate system, and tool offsets. Write a sample CNC program demonstrating the use of work offset (G54) and tool length compensation (G43). (14 marks)

Module 5

19 Prepare a part program to produce the part shown in fig. from a 55 mm diameter workpiece. The maximum cutting speed can be taken as 30 m/min and the maximum feed rate is 0.3 mm/rev. Limit the maximum spindle speed at 1000 rpm. (14 marks)



OR

20 Explain the ISO coding system for turning inserts. Describe each element of the code with a suitable example. (14 marks)

B24ME4G21	INTRODUCTION TO BUSINESS ANALYTICS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Business Analytics integrates statistical methods, data analysis, machine learning, and optimization techniques to transform data into actionable insights. This course provides a comprehensive introduction to the foundations of business analytics, covering descriptive, predictive, and prescriptive approaches. It equips students with the necessary skills to analyze business data, develop forecasting models, and formulate optimization problems for improved decision-making. The course also emphasizes the use of modern analytical tools and real-world applications across domains such as operations, supply chain, marketing, and finance. By bridging analytical concepts with practical implementation, the course prepares students to address complex business challenges in engineering and management contexts.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the fundamental concepts of business analytics, including its types, frameworks, and applications in data-driven decision-making. (Cognitive Knowledge Level: Understand)
CO 2	Describe the types of business data, data handling processes, and analytics lifecycle frameworks used in business analytics. (Cognitive Knowledge Level: Understand)
CO 3	Apply descriptive and inferential statistical methods to analyze business data and interpret results using appropriate data visualization techniques. (Cognitive Knowledge Level: Apply)
CO 4	Develop predictive models using regression and classification techniques, and apply forecasting methods in business scenarios. (Cognitive Knowledge Level: Apply)
CO 5	Apply optimization techniques to solve prescriptive analytics problems in business decision-making (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

COs \POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	-	1	–	–	–	–	1	1
CO2	2	2	1	-	2	–	–	–	–	1	-
CO3	3	3	2	2	3	–	–	–	–	2	1
CO4	3	3	3	2	3	–	–	–	–	2	-
CO5	3	3	3	3	3	–	–	–	–	2	2

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	20	30
Understand	60	40	40
Apply		40	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Foundations of Business Analytics (6 hours)

Introduction to business analytics: meaning, scope, and evolution. Framework of business analytics and data-driven decision-making in business and engineering systems. Types of analytics: descriptive, inferential, predictive, and prescriptive. Business problems and analytical modeling approaches. Overview of analytics tools, including spreadsheets, programming platforms, and enterprise analytics systems. Applications in marketing, finance, operations, manufacturing, and supply chain systems.

MODULE 2: Business Data and Data Handling (7 hours)

Business data: types and sources in organizational decision systems, Measurement scales and data collection concepts, Web scraping, ERP, Data-driven decision making in service industries, Supply chain structure and key performance metrics, Inventory Management. Analytics lifecycle and CRISP–DM framework. Data handling: data quality issues, preprocessing, cleaning, and preparation. Data governance and ethical considerations.

MODULE 3: **Descriptive and Inferential Analytics (8 Hours)**

Descriptive analytics: measures of central tendency and dispersion, frequency distributions, quartiles, and interquartile range. Exploratory Data Analysis (EDA), correlation analysis, and pattern identification in business data. Data visualization techniques: charts, histograms, scatter plots, box plots, and dashboards. Introduction to inferential analytics: confidence intervals, hypothesis testing, and analysis of variance (ANOVA).

MODULE 4: Predictive Analytics and Forecasting (8 hours)

Role of predictive analytics in business systems. Concepts of machine learning models in business analytics. Prediction and classification models: regression, logistic regression, and decision trees. Model evaluation and validation techniques. Association and clustering techniques in business scenarios. Software tools for predictive analytics. Forecasting concepts and demand prediction: moving averages, exponential smoothing, time-series models, and regression-based forecasting.

MODULE 5: Prescriptive Analytics and Optimization (7 hours)

Prescriptive analytics for decision modeling and optimization. Formulation of optimization problems using decision variables, objective functions, and constraints (numerical examples). Linear programming and mixed integer linear programming (MILP) models for business applications. Introduction to optimization solvers (spreadsheets, IBM CPLEX). Heuristic and metaheuristic approaches (basics). Simulation methods for decision-making under uncertainty.

Text Books

1. U. Dinesh Kumar, B. S. Sahay, *Business Analytics: The Science of Data-Driven Decision Making,* Pearson India.
2. James R. Evans, *Business Analytics,* Pearson India.

Reference Books

1. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, *Business Analytics: Descriptive, Predictive, Prescriptive*, Cengage.
2. Anil Maheshwari, *Data Analytics*, McGraw Hill Education.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**6**
1.1	Introduction to business analytics: meaning, scope, and evolution	1
1.2	Framework of business analytics and data-driven decision-making in business and engineering systems.	2
1.3	Types of analytics: descriptive, inferential, predictive, and prescriptive	1
1.4	Business problems and analytical modeling approaches, Overview of analytics tools: spreadsheets, programming platforms, and enterprise analytics systems	1
1.5	Applications in marketing, finance, operations, manufacturing, and supply chain systems	1
	Module 2	**7**
2.1	Business data: types and sources in organizational decision systems	1
2.2	Measurement scales and data collection concepts.	1
2.3	Web scraping, ERP, and data-driven decision-making in service industries.	1
2.4	Supply chain structure, key performance metrics, and inventory management.	1
2.5	Analytics lifecycle and CRISP–DM framework.	1
2.6	Data quality issues, preprocessing, cleaning, and preparation	1
2.7	Data governance and ethical considerations	1
	Module 3	**8**
3.1	Descriptive analytics: measures of central tendency and dispersion, frequency distributions, quartiles, and interquartile range.	1
3.2	Exploratory Data Analysis (EDA), correlation analysis, and pattern identification in business data	1
3.3	Data visualization techniques: charts, histograms, scatter plots, box plots, and dashboards.	2
3.4	Introduction to inferential analytics: confidence intervals, hypothesis testing	2
3.5	Analysis of variance (ANOVA)	2
	Module 4	**8**
4.1	Role of predictive analytics in business systems, Concepts of machine learning models in business analytics.	1
4.2	Prediction and classification models: regression, logistic regression,	2

	and decision trees, Model evaluation and validation techniques, Software tools for predictive analytics.	
4.3	Association and clustering techniques in business scenarios.	1
4.4	Forecasting concepts and demand prediction: moving averages, exponential smoothing.	2
4.5	Time-series models and regression-based forecasting	2
	Module 5	**7**
5.1	Prescriptive analytics for decision modeling and optimization. Formulation of optimization problems.	2
5.2	Linear programming and mixed integer linear programming (MILP) models for business applications	1
5.3	Numerical Examples	1
5.4	Introduction to optimization solvers (Spreadsheets and IBM CPLEX)	1
5.5	Heuristic and metaheuristic approaches: basics	1
5.6	Simulation methods for decision-making under uncertainty	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1)

1. What is business analytics, and why is it important in decision-making?
2. Explain the major types of business analytics with examples.
3. Describe the framework of business analytics in organizations.
4. Discuss the applications of business analytics in business and engineering systems.

Course Outcome 2 (CO2

1. Explain the major types and sources of business data.
2. What are measurement scales, and why are they important in data analysis?
3. Describe the analytics lifecycle and the CRISP–DM framework.
4. Explain the importance of data preprocessing, cleaning, and governance in business analytics.

Course Outcome 3 (CO3)

1. Explain the use of measures of central tendency and dispersion in business data analysis.
2. What is Exploratory Data Analysis, and how is it useful in business analytics?
3. Describe the role of data visualization techniques in analyzing business data.
4. Explain confidence intervals, hypothesis testing, and ANOVA in business analytics.

Course Outcome 4 (CO4)

1. What is predictive analytics, and how is it used in business systems?
2. Explain regression and logistic regression models used in business analytics.
3. Describe the use of decision trees, association, and clustering techniques in business scenarios.
4. Explain the major forecasting methods used for demand prediction in business.

Course Outcome 5 (CO5)

1. What is prescriptive analytics, and how does it support decision-making?
2. Explain the formulation of an optimization problem using decision variables, objective function, and constraints.
3. Describe linear programming and mixed integer linear programming models for business applications.
4. Explain the role of optimization solvers, heuristics, and simulation in prescriptive analytics.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4G21**

Course Name: **INTRODUCTION TO BUSINESS ANALYTICS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Explain the meaning and scope of business analytics.

2 Distinguish between descriptive, predictive, and prescriptive analytics.

3 Explain the major types and sources of business data used in organizations.

4 Describe the analytics lifecycle.

5 Explain the importance of measures of central tendency and dispersion in business data analysis.

6 Describe the role of data visualization and Exploratory Data Analysis in understanding business data.

7 Explain the role of predictive analytics in business systems.

8 Describe the significance time series analysis.

9 Explain the basic components of an optimization problem in prescriptive analytics.

10 Describe the role of linear programming in business decision-making.

PART B

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

Module 1

11 Explain how business analytics has emerged as a strategic tool for modern organizations and discuss its importance in managerial decision-making. (14 marks)

OR

12 Discuss the role of analytics tools and enterprise analytics systems in solving business and engineering problems. (14 marks)

Module 2

13 What is data life-cycle? Explain the key steps involved in data preprocessing. (14 marks)

OR

14 Discuss supply chain structure, inventory management, and key performance metrics in the context of data-driven decision-making. (14 marks)

Module 3

15 Explain the measures of central tendency and dispersion, frequency distributions, quartiles, and interquartile range used in descriptive analytics. (14 marks)

OR

16 Discuss confidence intervals and hypothesis testing in inferential analytics. (14 marks)

Module 4

17 Discuss the concepts of supervised and unsupervised learning and explain their roles in predictive analytics. (14 marks)

OR

18 Explain linear regression, classification, and clustering problems in business scenario with suitable examples. (14 marks)

Module 5

19 Explain how optimization models are formulated for business applications and discuss their practical relevance in decision-making. (14 marks)

OR

20 A company manufactures two products, A and B. Each unit of product A yields a profit of ₹40, and each unit of product B yields a profit of ₹30. Product A requires 2 hours of machining and 1 hour of assembly, while product B requires 1 hour of machining and 2 hours of assembly. The company has 100 hours of machining time and 80 hours of assembly time available. Formulate the linear programming model to determine the optimal product mix that maximizes profit. (14 marks)

B24ME4G22	PATENTS AND INTELLECTUAL PROPERTY RIGHTS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Innovation and technological advancement are central to mechanical engineering practice. Engineers must understand how to protect, manage, and commercialize their inventions and designs. This course introduces students to the legal, procedural, and strategic aspects of Intellectual Property Rights (IPR), with special emphasis on patents relevant to engineering innovations in India. The course equips students with knowledge of patent drafting, filing procedures, infringement issues, and technology transfer mechanisms within the Indian and global context.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the fundamental concepts of Intellectual Property Rights and their significance in engineering innovation (Cognitive Knowledge Level: Understand).
CO 2	Describe the provisions of the Patents Act, 1970 and the criteria for patentability in India (Cognitive Knowledge Level: Understand).
CO 3	Outline the procedure for patent filing, examination, and grant in India and international filing routes (Cognitive Knowledge Level: Understand).
CO 4	Explain different forms of IPR, infringement issues, and legal remedies relevant to engineering applications (Cognitive Knowledge Level: Understand).
CO 5	Describe the concepts of technology transfer, licensing, and commercialization of patents in engineering industries (Cognitive Knowledge Level: Understand).

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	2	1	–	–	–	2	1	–	–	–	2
CO 2	3	2	–	–	–	2	–	–	–	–	2
CO 3	2	2	–	–	1	1	–	–	–	1	2
CO 4	1	2	–	–	–	2	–	2	–	–	2
CO 5	1	1	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	40	40	40
Understand	60	60	60
Apply			
Analyse			
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Introduction to Intellectual Property Rights (6 Hours)

Concept and need for Intellectual Property Rights – Types of IPR: Patents, Copyrights, Trademarks, Industrial Designs, Geographical Indications, Trade Secrets – Role of IPR in engineering innovation – International conventions and agreements (WIPO, TRIPS Agreement) – Overview of Indian IPR framework – Importance of IPR for mechanical engineers and startups.

Module 2: Indian Patent Law and Patentability (8 Hours)

The Patents Act, 1970 and its amendments – Definition of patent – Criteria for patentability: novelty, inventive step, industrial applicability – Non-patentable subject matter – Types of patents – Patent search and prior art search – Patent specification: provisional and complete specification – Structure of patent document – Claims drafting basics – Patent publication and examination process in India.

Module 3: Patent Filing, Examination and Grant Procedure (7 Hours)

Patent filing procedure in India – Role of Indian Patent Office – Examination process and First Examination Report (FER) – Responses and amendments – Opposition procedures (pre-grant and post-grant) – Patent grant and term of protection – Maintenance and renewal of patents – International patent filing routes (PCT overview) – Introduction to patent databases (Indian Patent Advanced Search System – InPASS, WIPO Patentscope).

Module 4: Other Forms of IPR and Infringement Issues (7 Hours)

Industrial Designs protection under the Designs Act, 2000 – Trademark protection under the Trade Marks Act, 1999 – Copyright protection for technical drawings and software – Trade secrets and confidential information – Patent infringement: types and remedies – Civil and criminal remedies – Case studies related to engineering patent disputes – Compulsory licensing provisions.

Module 5: Technology Transfer, Commercialization and IPR Management (8 Hours)

Technology transfer concepts – Licensing and assignment of patents – Royalty and valuation of intellectual property – IPR management in organizations – Role of IPR in startups and entrepreneurship – Technology incubation and innovation ecosystem in India – Government initiatives supporting IPR (Startup India, Make in India – overview) – Ethical considerations in patenting – Emerging issues: green patents, digital manufacturing and AI-related inventions – Case studies in mechanical engineering innovations.

Textbooks

1. Prabuddha Ganguli, *Intellectual Property Rights: Unleashing the Knowledge Economy*, McGraw-Hill.
2. P. Narayanan, *Patent Law in India*, Eastern Law House.
3. V. K. Ahuja, *Law Relating to Intellectual Property Rights*, LexisNexis.

References

1. W. R. Cornish, *Intellectual Property: Patents, Copyrights, Trademarks and Allied Rights*, Sweet & Maxwell.
2. *World Intellectual Property Organization (WIPO)* – Official publications and guidelines.
3. *Controller General of Patents, Designs & Trade Marks* – Government of India manuals and practice guides.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**6**
1.1	Introduction to Intellectual Property Rights (IPR); Need and importance of IPR in engineering	2
1.2	Types of IPR – Patents, Copyrights, Trademarks, Industrial Designs, GI, Trade Secrets	2
1.3	International agreements (WIPO, TRIPS); Indian IPR framework; Relevance to Mechanical Engineers	2
	Module 2	**8**
2.1	Overview of the Patents Act, 1970; Amendments and scope	2
2.2	Patentability criteria – Novelty, Inventive step, Industrial applicability; Non-patentable subject matter	2
2.3	Types of patents; Patent search and prior art search; Introduction to patent databases	2
2.4	Patent specification – Provisional and complete specification; Structure of patent document; Basics of claim drafting	2
	Module 3	**7**
3.1	Patent filing procedure in India; Role of Indian Patent Office	1
3.2	Examination process; First Examination Report (FER); Amendments and responses	2
3.3	Opposition procedures; Grant, term, renewal and maintenance of patents	2
3.4	International patent filing routes (PCT overview); Introduction to InPASS and WIPO databases	2
	Module 4	**7**
4.1	Industrial Designs under the Designs Act, 2000; Trademarks under the Trade Marks Act, 1999	2
4.2	Copyrights in engineering drawings and software; Trade secrets	2
4.3	Patent infringement – Types, remedies, civil and criminal liabilities; Case discussion	3
	Module 5	**8**
5.1	Technology transfer concepts; Licensing and assignment of patents	2

5.2	Royalty, valuation of IP; IPR management in organizations and startups	2
5.3	Government initiatives (Startup India, Make in India – overview); Innovation ecosystem in India	2
5.4	Ethical issues in patenting; Green patents; Emerging issues (AI, digital manufacturing); Case study discussion	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. What is the role of IPR in engineering innovation?
2. What is the significance of the TRIPS Agreement?
3. Explain the international framework governing IPR, including the role of World Intellectual Property Organization and TRIPS.
4. Discuss the Indian IPR framework and its importance for startups and engineering enterprises.

Course Outcome 2 (CO2):

1. List any three non-patentable subject matters under Indian Patent Law.
2. Differentiate between provisional and complete specification.
3. Explain the structure and components of a patent document.
4. Describe the process of conducting a patent search and prior art analysis.

Course Outcome 3 (CO3):

1. What is the term of a patent in India?
2. What is the Patent Cooperation Treaty (PCT)?
3. Explain the procedure for grant, renewal, and maintenance of patents in India.
4. Describe international patent filing routes and the significance of the PCT system.

Course Outcome 4 (CO4):

1. What is patent infringement?
2. State any two remedies available for patent infringement.
3. Explain different types of patent infringement and the legal remedies available.
4. Discuss copyright and trade secret protection in engineering contexts with examples.

Course Outcome 5 (CO5)

1. What is royalty?
2. State any three government initiatives supporting innovation in India.
3. Explain the role of IPR management in startups and engineering industries.
4. Discuss ethical issues in patenting and emerging trends such as green patents and AI-related inventions.

MODEL QUESTION PAPER

QP CODE: Pages: 2

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4G22**

Course Name: **PATENTS AND INTELLECTUAL PROPERTY RIGHTS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Define Intellectual Property Rights (IPR).
2. List any four types of IPR.
3. Define patentability criteria.
4. What is meant by “inventive step”?
5. What is the First Examination Report (FER)?
6. Define patent opposition.
7. What is industrial design protection?
8. Define trademark.
9. Define technology transfer.
10. What is patent licensing?

PART B

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

Module 1

11. Explain the international framework governing IPR, including the role of World Intellectual Property Organization and TRIPS. (14 marks)

OR

12. Discuss the Indian IPR framework and its importance for startups and engineering enterprises. (14marks)

Module 2

13. Explain the structure and components of a patent document. (14marks)

OR

14. Describe the process of conducting a patent search and prior art analysis. (14marks)

Module 3

15. Explain the procedure for grant, renewal, and maintenance of patents in India. (14marks)

OR

16. Describe international patent filing routes and the significance of the PCT system. (14marks)

Module 4

17. Explain different types of patent infringement and the legal remedies available. (14marks)

OR

18. Discuss copyright and trade secret protection in engineering contexts with examples. (14marks)

Module 5

19. Explain the role of IPR management in startups and engineering industries. (14 marks)

OR

20. Discuss ethical issues in patenting and emerging trends such as green patents and AI-related inventions. (14 marks)

B24ME4G23	FUNDAMENTALS OF LOGISTICS AND SUPPLY CHAIN MANAGEMENT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Logistics and Supply Chain Management (LSCM) are essential for the efficient movement of materials, information, and services across modern organizations. In today's interconnected and digital economy, sectors such as manufacturing, information technology, healthcare, retail, and e-commerce rely on effective logistics and supply chain systems to ensure timely delivery, cost efficiency, and customer satisfaction. This course introduces students from various engineering disciplines to the fundamental concepts and practices of logistics and supply chain management, including logistics operations, supply chain structures, sourcing, transportation, inventory management, and supply chain planning. It also provides an overview of emerging trends such as green logistics, digital supply chains, and resilient supply chain systems through practical examples and case studies from diverse industries.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the fundamental concepts of logistics, logistics stakeholders, warehousing, and logistics service providers in modern industrial and service sectors (Cognitive Knowledge Level: Understand).
CO 2	Describe reverse logistics, green logistics, lean logistics, and emerging technological trends influencing modern logistics systems (Cognitive Knowledge Level: Understand).
CO 3	Explain the fundamentals of supply chain management, supply chain structures, and supply chain network design concepts (Cognitive Knowledge Level: Understand)
CO 4	Apply supply chain coordination concepts including sourcing strategies, supplier evaluation, and performance measurement in supply chains (Cognitive Knowledge Level: Apply)
CO 5	Apply basic supply chain planning concepts such as demand forecasting, transportation, capacity planning, and inventory management in logistics decision-making (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	40	30
Understand	60	40	40
Apply		20	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Introduction to Logistics (7 Hours)

Introduction to Logistics: Concept, scope and importance of logistics in modern business; Logistics design and management; Logistics stakeholders and modern logistics concepts; Role of logistics in manufacturing and service sectors; Manufacturing logistics: national and international scenario; Storage and warehousing fundamentals; Logistics service providers (3PL, 4PL concepts); Outsourcing logistics.

Industry scenario: Logistics in the e-commerce industry, international logistics, international market penetration strategies; Logistics key performance indicators (KPIs): transportation, supply, distribution, warehousing and order management; Tools for improving logistics efficiency; Case studies.

Module 2: Sustainable and Emerging Trends in Logistics (7 Hours)

Reverse logistics: concepts and applications; Performance measures in reverse logistics; Green Supply Chain Management (GSCM); Key technologies in green logistics for minimizing carbon emissions; Implementing green logistics practices; Lean logistics: principles and applications;

Digital transformation in logistics: Internet of Things (IoT), RFID, automation, and data analytics; Trends in logistics and supply chain integration; Logistics versus Supply Chain Management; Logistical components of the supply chain; Case studies.

Module 3: Fundamentals of Supply Chain Management (7 Hours)

Fundamentals of Supply Chain Management (SCM); Supply chain decisions: strategic, tactical and operational; Types of supply chain models; Supply chain operations: manufacturing versus service supply chains; Examples from manufacturing and service sectors;

Principal streams of supply chain: material flow, information flow, and financial flow; Objectives of supply chain networks; Factors influencing supply chain network decisions; Framework for network design decisions; Case studies.

Module 4: Supply Chain Coordination and Performance (7 Hours)

Supply chain uncertainty and risks; Strategies to mitigate supply chain uncertainty and disruptions; Supply chain operational views: SCOR model; Cyclic view and push–pull view of supply chains; Introduction to supply chain analytics and modelling concepts; Supply chain control towers and digital supply chain visibility; Supply chain drivers; Strategic sourcing; Supplier selection and management; Vendor rating and evaluation; Global sourcing; Coordination in supply chains; Supply chain performance measurement; Introduction to facility location decisions; Case studies.

Module 5: Planning and Future Supply Chains (8 Hours)

Demand forecasting: basic concepts and methods; Facility capacity planning; Overview of sequencing and scheduling in logistics operations; Transportation decisions and modes; Introduction to transportation and assignment problems in logistics decision making; Inventory management concepts; Designing smart, resilient and sustainable supply chains; Smart practices in SCM: 21st century digital supply chains; Supply Chain 4.0 and its benefits; Financing global supply chains; Sustainable supply chains; Designing emergency and humanitarian supply chains; Future perspectives of SCM; Case studies.

Textbooks

1. Sunil Chopra and Peter Meindl, *Supply Chain Management: Strategy, Planning and Operation*, Pearson Education.
2. Martin Christopher, *Logistics and Supply Chain Management*, Pearson Education.

Reference Books

1. David Simchi-Levi, Philip Kaminsky, and Edith Simchi-Levi, *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*, McGraw-Hill.
2. David Bloomberg, Stephen LeMay, and Joe Hanna, *Logistics,* Prentice Hall.
3. Donald J. Bowersox, David J. Closs, and M. Bixby Cooper, *Supply Chain Logistics Management,* McGraw-Hill.
4. Thomas Teufel, Jurgen Rohricht, and Peter Willems, *SAP Processes: Logistics,* Addison-Wesley.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Introduction to logistics: concept, scope, and importance; logistics design and management	2
1.2	Logistics stakeholders; manufacturing logistics – national and international scenario	2
1.3	Storage and warehousing concepts; logistics service providers and outsourcing logistics	2
	Logistics KPIs and tools for improving logistics efficiency; case discussion	1
	Module 2	**7**
2.1	Reverse logistics: concepts and applications; performance measures in reverse logistics	2
2.2	Green logistics and Green Supply Chain Management	2
2.3	Lean logistics: principles and applications	2
2.4	Technological advancements in logistics; logistics vs SCM; case discussion	1
	Module 3	**7**
3.1	Fundamentals of Supply Chain Management; supply chain decisions	2
3.2	Types of supply chain models; supply chain operations	2
3.3	Manufacturing vs service supply chains; principal supply chain flows	2
3.4	Objectives of supply chain networks and factors influencing network design	1
	Module 4	**7**
4.1	Supply chain uncertainty and risk mitigation strategies	2
4.2	Supply chain operational views: SCOR model, cycle view, push–	2

	pull view	
4.3	Strategic sourcing; supplier selection and vendor evaluation	2
	Supply chain coordination, performance measurement, and facility location concepts	1
	Module 5	**8**
5.1	Demand forecasting fundamentals	2
5.2	Capacity planning and scheduling concepts	2
5.3	Transportation decisions and inventory management fundamentals	2
5.4	Smart, resilient, and sustainable supply chains; Supply Chain 4.0 and future trends	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Define logistics and explain its importance in modern organizations.
2. Identify the major stakeholders involved in logistics systems.
3. What are logistics service providers? Give examples.
4. Explain the design and management of logistics systems and discuss the role of logistics service providers in modern supply chains.

Course Outcome 2 (CO2):

1. Define reverse logistics with a suitable example.
2. What is Green Supply Chain Management?
3. State the principles of lean logistics.
4. Explain the concept of reverse logistics and discuss its performance measures with suitable examples.

Course Outcome 3 (CO3):

1. Define Supply Chain Management.
2. Explain the three main flows in a supply chain.
3. List the objectives of supply chain networks.
4. Explain the fundamentals of Supply Chain Management and discuss the different types of supply chain models.

Course Outcome 4 (CO4):

1. What is supply chain uncertainty?
2. Define the SCOR model.
3. What is strategic sourcing?
4. Explain different types of supply chain uncertainties and discuss strategies to mitigate them.

Course Outcome 5 (CO5)

1. Define demand forecasting in supply chains.
2. What is capacity planning?
3. List the major modes of transportation in logistics.
4. Explain demand forecasting techniques and their importance in supply chain planning.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4G23**

Course Name: **FUNDAMENTALS OF LOGISTICS AND SUPPLY CHAIN MANAGEMENT**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What are logistics service providers? Give examples.
2. List the key performance indicators (KPIs) used in logistics operations.
3. State the principles of lean logistics.
4. List any four technologies used in modern logistics systems.
5. List the objectives of supply chain networks.
6. Differentiate between manufacturing and service supply chains.
7. What is strategic sourcing?
8. List the factors considered in supplier evaluation.
9. List the major modes of transportation in logistics.
10. Define sustainable supply chains.

PART B

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

Module 1

11. Discuss the key performance indicators (KPIs) used to evaluate logistics efficiency with suitable examples. (14 marks)

OR

12. Explain the concepts of warehousing, storage systems, and outsourcing logistics in modern industries. (14marks)

Module 2

13. Discuss Green Supply Chain Management and technologies used to minimize carbon emissions in logistics operations. (14marks)

OR

14. Explain the principles of lean logistics and discuss recent technological trends influencing logistics systems. (14marks)

Module 3

15. Discuss the objectives of supply chain networks and factors influencing supply chain network design decisions. (14marks)

OR

16. Compare supply chain operations in manufacturing and service sectors with suitable examples. (14marks)

Module 4

17. Explain strategic sourcing and supplier selection methods used in supply chain management. (14marks)

OR

18. Discuss supply chain operational views including the SCOR model, cycle view, and push–pull view. (14marks)

Module 5

19. Explain how smart, resilient, and sustainable supply chains can be designed using modern supply chain practices. (14 marks)

OR

20. Discuss transportation decisions and capacity planning in logistics systems. (14 marks)

B24ME4G24	RENEWABLE ENERGY ENGINEERING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces the principles and technologies of renewable energy systems with a focus on sustainable energy solutions. It begins with an overview of the global and national energy scenario, highlighting the need for alternative energy sources and the fundamentals of solar radiation. The course then explores various solar energy conversion systems, including thermal and photovoltaic technologies, along with their storage methods and practical applications. It further covers wind energy systems, ocean energy technologies, and geothermal resources, emphasizing their working principles and performance characteristics. In addition, the course addresses biomass and hydrogen energy conversion techniques, followed by economic analysis methods to evaluate the feasibility of renewable energy systems. Overall, the course equips students with the knowledge required to understand, analyze, and apply renewable energy technologies in real-world applications.

Prerequisites

Nil

Course Outcomes

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

CO 1	Describe renewable energy sources, assess their implications, and estimate solar radiation at a location. (Cognitive Knowledge Level: Understand)
CO 2	Explain solar energy collectors, storages, solar cell characteristics and applications. (Cognitive Knowledge Level: Understand)
CO 3	Apply knowledge of different types of wind power machines and control strategies of wind turbines. (Cognitive Knowledge Level: Apply)
CO 4	Apply knowledge of ocean energy conversion devices and geothermal energy sources. (Cognitive Knowledge Level: Apply)
CO 5	Describe biomass energy conversion devices and calculate the net present value and payback period. (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										
CO 2	3	3			1	1	1				1
CO 3	3	3			1	1	1				1
CO 4	3	3			1	1	1				1
CO 5	3	3			1	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	60	40
Apply		20	40
Analyse			
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Energy Scenario and Solar Radiation Fundamentals (6 hours)

Introduction: The Energy Scenario- Commercial energy sources -World's production and reserves- India' Production and reserves, Energy Alternatives, Need for alternatives –solar option- nuclear options.

Principles of solar radiation: Solar radiation outside the earth's atmosphere and at the earth's surface, Solar Constant, Basic Sun-Earth Angles, Instruments for measuring solar radiation and sunshine, Solar radiation data.

MODULE 2: Solar Energy Conversion Systems and Applications (8 hours)

Solar Energy collectors: Solar thermal collectors -Flat plate collectors –Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) –Solar Air Heaters.

Solar thermal electric power generation -Thermal Energy storage, sensible heat storage, latent heat storage, Thermo chemical storage, photovoltaic system for power generation, Solar pond -Solar Cells-Types of solar cells, principle of working and performance characteristics, Production process- Block diagram only.

Applications- Solar space heating and cooling of buildings, solar pumping, solar cooker, solar still, solar drier, solar refrigeration and air-conditioning, heliostat, solar furnace.

MODULE 3: Wind Energy Conversion Systems (7 hours)

Wind Energy- classification of wind turbines and power performance curve, Energy in wind, calculation of energy content, Power coefficients, Betz limit theory, tip speed ratio, solidity of turbine' power control strategies, Basic principles of Wind Energy Conversion Systems (WECS), Classification of Wind Energy Conversion Systems, Parts of WECS.

MODULE 4: Ocean and Geothermal Energy Systems (7 hours)

Ocean Energy – Devices for Wave Energy conversion, Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system, Methods of OTEC power generation – Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle (block diagram description of OTEC); Geothermal energy: Introduction, hot dry rock resources, magma resources, vapor and liquid dominated systems, binary cycle, advantages and disadvantages.

MODULE 5: Biomass, Hydrogen Energy, and Economic Analysis (8 hours)

Biomass Energy- Biomass conversion technologies –Bio Gasification, Bio ethanol, Bio Diesel, Biogas production from waste biomass, factors affecting biogas generation Bio Gas - KVIC and Janata model.

Hydrogen Energy – various routes for production of Hydrogen energy.

Economic Analysis – Initial and annual cost, basic definitions, present worth calculations, life cycle cost, economic analysis of add on solar system, payback period.

Text Books

1. S P Sukhatme, J K Nayak, *Solar Energy: Principles of Thermal Collection and Storage*, Mc Graw Hill.

2. Tiwari G N, Ghosal M K, *Fundamentals of renewable energy sources*, Alpha Science International Ltd.
3. Jefferson W Tester et.a., *Sustainable Energy Choosing among options*, PHI.

Reference Books

1. D.P. Kothari, *Renewable energy resources and emerging technologies*, PHI.
2. Mehmet Kanoğlu Yunus A. Çengel John M. Cimbala, *Fundamentals and Applications of Renewable Energy,* Mc Graw Hill.
3. Roland Wengenmayr, Thomas Buhrke, *Renewable Energy: Sustainable energy concepts for the future*, Wiley – VCH.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**6**
1.1	Commercial energy sources -World's production and reserves India' Production and reserves.	1
1.2	Energy Alternatives- Need for alternatives –solar options.	1
1.3	Solar radiation outside the earth's atmosphere and at the earth's surface, Solar Constant.	2
1.4	Basic Sun-Earth Angles, Instruments for measuring solar radiation and sunshine, Solar radiation data.	2
	Module 2	**8**
2.1	Solar thermal collectors -Flat plate collectors.	1
2.2	Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector.	1
2.3	Solar Air Heaters-types - Solar thermal electric power generation Thermal Energy storage, sensible heat storage, latent heat storage, Thermo chemical storage.	1
2.4	Photovoltaic system for power generation.	1
2.5	Solar Cells-Types - principle of working and performance characteristics, Production process- Block diagram only.	2
2.6	Applications- Solar space heating and cooling of buildings, solar pumping, solar cooker, solar still, solar drier, solar refrigeration and air-conditioning, heliostat, solar furnace.	2
	Module 3	**7**
3.1	Classification of wind turbines.	2
3.2	Power performance curve, Energy in wind, Calculation of energy content.	1
3.3	Power coefficients, Betz limit theory, Tip speed ratio, Solidity of turbine' power control strategies.	2
3.4	Basic principles of Wind Energy Conversion Systems (WECS), Classification of WECS, Parts of WECS.	2
	Module 4	**7**
4.1	Devices for Wave Energy conversion Ocean Thermal Energy	2

	Conversion (OTEC): Principle of OTEC system.	
4.2	Methods of OTEC power generation – Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle (block diagram description of OTEC).	2
4.3	Geothermal energy: Introduction, Hot dry rock resources, Magma resources.	2
4.4	Vapor and liquid dominated systems, Binary cycle, Advantages and disadvantages.	1
	Module 5	**8**
5.1	Biomass conversion technologies –Bio Gasification, Bio ethanol, Bio Diesel.	2
5.2	Biogas production from waste biomass, Factors affecting biogas generation Bio Gas -KVIC and Janata model.	1
5.3	Hydrogen Energy – Various routes for production.	1
5.4	Economic Analysis – Initial and annual cost, Basic definitions.	2
5.5	Present worth calculations, Repayment of loan in equal annual installments, Annual savings, Cumulative saving and Life cycle cost.	1
5.6	Economic analysis of add on solar system, Payback period (derivation).	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. What are the main renewable energy sources? Advantages and limitations
2. What is energy efficiency? How is it different from renewable energy use?
3. Define terms: Angle of Incidence, Declination, Solar constant.

Course Outcome 2 (CO2):

1. Differentiate Discuss different types of solar collectors
2. Discuss about different types of thermal storage devices
3. Draw the I-V characteristics of Solar cell under varying temperature and irradiation level

Course Outcome 3 (CO3):

1. Types of wind turbine and components.
2. Difference between wind mill and wind turbine.
3. Explain importance of drag and lift force in wind power generation.

Course Outcome 4 (CO4):

1. Explain with neat sketch the working of hybrid OTEC system
2. Explain with neat sketch the vapour dominated geothermal system

Course Outcome 5 (CO5)

1. Distinguish between Fixed dome plant and floating dome type biomass plant.
2. Write a short note on solar saving.
3. Derive expression for payback period

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: **B24ME4G24**

Course Name: **RENEWABLE ENERGY ENGINEERING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1		Discuss in brief advantages of renewable energy.
2		Explain the following terms related to solar geometry (i) Hour Angle ((ii) Zenith Angle (iii) Surface azimuth angle.
3		List different types of solar collectors.
4		Discuss about solar pond
5		List the different methods used to estimate wind speed at a location.
6		What are the advantages of wind energy conversion systems?
7		List the geothermal resources.
8		Discuss advantages and disadvantages of a tidal power plant
9		Name the different processes used for hydrogen production
10		List the need for economic analysis of renewable energy system.

PART B

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

Module 1

11		Elucidate the necessity of energy storage in the context of renewable sources of energy.	(14 marks)
		OR	
12	a.	Calculate the number of daylight hours in Srinagar for 22nd June. The latitude of Srinagar as 34º05'N.	(4 Marks)
	b.	Compare the construction and working of Pyranometer and Pyrheliometer.	(10 Marks)

Module 2

13 a. How solar thermal power plants classified. List the methods for converting solar energy into electric power. (10 Marks)

b. Briefly explain the applications of a solar PV system. (4 Marks)

OR

14 a. Draw and explain the operation of flat plate collectors. (10 Marks)

b. Explain the thermal methods of energy storage. (4 Marks)

Module 3

15 With a neat diagram explain the construction of a propeller type wind power System. (14 marks)

OR

16 a. Derive the expression for power in the wind turbine. (7 Marks)

b. Explain control mechanism in wind turbines. (7 Marks)

Module 4

17 State the principle of Ocean Thermal Energy Conversion (OTEC). Explain working of closed cycle OTEC system. (14 Marks)

OR

18 Explain binary cycle Geothermal system. (14 Marks)

Module 5

19 Explain the construction and working of KVIC (floating type) bio gas plant. (14 marks)

OR

20 a. Define (1) Payback time (2) Return on investment, (3) Life cycle cost (6 Marks)

b. A solar PV system consisting with two lamps, a battery and other associated components cost Rs. 55000. The cost of conventional energy saved due to its installation is Rs. 4000 in the first year and this cost inflates at the rate of 5 % per year. Assume discounting rate is 9%. Calculate the payback period of the system with and without discounting. (8 Marks)

B24ME4G25	INTRODUCTION TO 3D PRINTING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces the fundamental principles and concepts of 3D Printing. It covers the various 3D Printing processes. The course also explains the scope and significance of 3D Printing in modern engineering. Emphasis is given to the wide range of applications of 3D Printing in different industrial sectors. This course helps students understand the importance and potential of 3D Printing in advanced product design and development.

Prerequisites

NIL

Course Outcomes

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

CO 1	Explain the significance and principles of 3D Printing (Cognitive Knowledge Level: Understand)
CO 2	Identify a suitable 3D printing process for a given product/application. (Cognitive Knowledge Level: Understand)
CO 3	Identify appropriate materials for the selected 3D printing process. (Cognitive Knowledge Level: Understand)
CO 4	Describe the model slicing process and tool path generation using slicing software in additive manufacturing systems. (Cognitive Knowledge Level: Understand)
CO 5	Apply knowledge to explain process–structure–property relationships and the effects of post-processing, defects, and residual stresses in 3D printing applications. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	3	3	2	2	1					1	
CO 2	3	2	2	1	2					1	
CO 3	3	3	2	1	2					1	
CO 4	3	3	2	2	2					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	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Introduction to 3D Printing (6 hours)

Introduction to layered manufacturing, Importance of 3D Printing, Introduction to reverse engineering: Traditional manufacturing vs 3D Printing, 3D Printing in Product Development, Basic Principles and Product Development, Classification of additive manufacturing processes, Benefits and Challenges in 3D Printing.

MODULE 2: Classification of 3D Printing Processes (8 hours)

Principle, process parameters, advantages, limitations, and applications of Fused Deposition Modelling (FDM), Selective Laser Sintering (SLS), Stereolithography (SLA), Laminated Object Manufacturing (LOM), Electron Beam Melting (EBM), Laser Engineering Net Shaping (LENS).

MODULE 3: Materials used in 3D Printing (6 hours)

Polymer materials (PLA, ABS, Nylon, Resin), Metal materials (Titanium, Aluminum, Stainless steel), Ceramic and composite materials, Material forms: filament, powder, liquid, Material properties and selection criteria, Mechanisms of material consolidation in FDM, SLS, and SLM

Polymers coalescence, sintering, photopolymerization, solidification rates, Meso and macro structures.

MODULE 4: Basic Concepts and Data Processing in 3D Printing (8 hours)

Basic Concepts and Digitization Techniques, Model Reconstruction, CAD Model Preparation, Part Orientation and Support Generation, Model Slicing and Tool Path Generation, Introduction to Slicing Software. STL File Format, STL File Issues and Tessellation, STL File Repair and Data Translation: Methods of STL file repair, generic solutions for error correction, use of translators, and introduction to newly proposed file formats for 3D Printing.

MODULE 5: Process evaluation and Post-processing (8 hours)

Process evaluation - process-structure relationships, structure-property relationships. Post-processing- post-processing methods and finishing techniques, Defects, residual stress, and distortion. Applications, Future trends and challenges in 3D printing.

Text Books

1. Gibson, I, Rosen, D W., and Stucker, B., *Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing*, Springer.
2. Chua C.K., Leong K.F., and Lim C.S., Rapid prototyping: Principles and applications, Third Edition, World Scientific Publishers.
3. Chee Kai Chua, Kah Fai Leong, *3D Printing and Additive Manufacturing: Principles and Applications*: Fourth Edition of Rapid Prototyping, World Scientific Publishers.
4. 4. Gebhardt A., *Rapid prototyping*, Hanser Gardener Publications, 2003

Reference Books

1. Liou, L.W., and Liou, F.W., *Rapid Prototyping and Engineering Applications: A Toolbox for Prototype Development*, CRC Press.

2. Kamrani, A.K., and Nasr, E.A., *Rapid Prototyping: Theory and Practice*, Springer.
3. Mahamood, R.M., *Laser Metal Deposition Process of Metals, Alloys, and Composite Materials*, Engineering Materials and Processes, Springer International Publishing.
4. Toyserkani, E., Khajepour, A., and Corbin, S.F., *Laser Cladding*, CRC Press.
5. Barnatt, C., *3D Printing*, ExplainingTheFuture.com.
6. Jacobs, P.F., *Stereolithography and Other RP&M Technologies: From Rapid Prototyping to Rapid Tooling*, Society of Manufacturing Engineers and the Rapid Prototyping Association, New York.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**6**
1.1	Introduction to layered manufacturing, Importance of 3D Printing, Introduction to reverse engineering: Traditional manufacturing vs 3D Printing	1
1.2	Basic Principles of 3D Printing: Creation of 3D Model, Conversion to Standard File Format, Slicing of the Model, Layer-by-Layer Fabrication, Bonding of Layers, Post-Processing.	2
1.3	Product Development Procedure in 3D Printing: Conceptual design and CAD modeling, Model verification and preparation, Part Orientation and Support Generation, Slicing and Tool Path Generation, Part Fabrication, Post-Processing, Inspection and Testing.	2
1.5	Classification of additive manufacturing processes, Benefits & Challenges in 3D Printing.	1
	Module 2	**8**
2.1	Fused Deposition Modelling (FDM): Principle, process with Process parameters (nozzle temperature, layer thickness, deposition speed), advantages, limitations and applications	2
2.2	Stereolithography (SLA): Principle and working process, Process parameters (laser power, layer thickness, curing time) Advantages and limitations and Applications.	2
2.3	Selective Laser Sintering (SLS): Principle and working process, Process parameters (laser power, scan speed, layer thickness, powder properties), Advantages and Applications.	1
2.4	Laminated Object Manufacturing (LOM): Principle and working process, Process parameters (layer thickness, bonding temperature, cutting speed), Advantages, limitations and Applications.	1
2.5	Electron Beam Melting (EBM): Principle and working process, Process parameters (beam power, scan speed, layer thickness), Advantages, limitations and Applications.	1

2.6	Laser Engineering Net Shaping (LENS): Principle and working process, Process parameters (laser power, powder feed rate, scan speed), Advantages, limitations and Applications.	1
	Module 3	**6**
3.1	Materials Used in 3D Printing: Polymer materials - PLA, ABS, Nylon, Resin, Metal materials - Titanium, Aluminum, Stainless steel, Ceramic and composite materials	2
3.2	Material forms: filament, powder, liquid, Material properties and selection criteria, Mechanisms of material consolidation in FDM, SLS, and SLM	2
3.3	Polymers coalescence, sintering, photopolymerization, solidification rates, Meso and macro structures.	2
	Module 4	**8**
4.1	Basic Concept - Digitization techniques: Methods of digitization-Contact scanning, Non-contact scanning (Laser scanning, Optical scanning, CT scanning), Model Reconstruction	2
4.2	Data Processing for 3D Printing Technology: CAD model preparation — Part Orientation and support generation, Model Slicing, Tool path Generation	2
4.3	STL File Format, STL File Issues and Tessellation	2
4.4	STL File Repair and Data Translation: Methods of STL file repair, generic solutions for error correction, use of translators, and introduction to newly proposed file formats for 3D Printing.	2
	Module 5	**8**
5.1	Process evaluation: process-structure relationships, structure-property relationships.	1
5.2	Post-processing- Support Removal, Surface Finishing, Heat treatment, shot peening, Hot isostatic pressing (HIPS), Micro finishing of AM parts, Support material removal, surface texture improvements	2
5.3	Defects in FDM, SLS, and SLM, Residual stress and distortion	2
5.4	Applications in aerospace, automotive, and medical fields	2
5.5	Future trends and challenges in 3D printing	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. What is 3D Printing?
2. What is STL file?
3. What is AM process chain?

Course Outcome 2 (CO2):

1. Brief the post processing types of LENS.

2. What are process variables in FDM?
3. What are the applications of EDM?

Course Outcome 3 (CO3):

1. Differentiate between filament, powder, and liquid forms of materials
2. List the common polymer materials used in additive manufacturing
3. What are the commonly used metal materials in additive manufacturing?

Course Outcome 4 (CO4):

1. What are digitization techniques in additive manufacturing?
2. Define model reconstruction in the context of 3D printing.
3. What is CAD model preparation for additive manufacturing?

Course Outcome 5 (CO5):

1. Define process evaluation in additive manufacturing.
2. What factors influence the process–structure relationship in 3D printing?
3. What are the common finishing techniques used after 3D printing?

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....
Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4P57**

Course Name: **INTRODUCTION TO 3D PRINTING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1	Define 3D Printing and briefly explain how it differs from traditional subtractive manufacturing methods.
2	Discuss two major advantages of 3D Printing compared to traditional manufacturing techniques, providing examples to support your answer.
3	Brief the LOM process.
4	What are the materials used in SLS
5	What are ceramic and composite materials?
6	Explain the concept of polymer coalescence
7	What is part orientation?
8	What is the purpose of support structures in 3D Printing
9	Mention any four applications of 3D printing technology
10	What are the major challenges faced in additive manufacturing?

PART B

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

Module 1

11	a.	Explain the steps in AM process chain.	(8 marks)
	b.	Write a note on the benefits and applications of AM.	(6 marks)

OR

12	a.	Explain in detail the classification of 3D Printing process on the basis of materials used.	(8 marks)
	b.	Compare and contrast Additive, Subtractive and Formative philosophies in manufacturing.	(6 marks)

Module II

13 a Brief about strength, Weakness and applications of SLA? (8marks)

b Explain the working principle and process variables of FDM. (6 marks)

OR

14 a. Brief about strength, Weakness and applications of SLS? (8 marks)

b. Explain the working principle and process variables of LOM. (6 marks)

Module III

15 a. Explain the effect of solidification rates on meso-structure and macro-structure in additively manufactured parts. (8 marks)

b. Discuss the properties of materials used in additive manufacturing and explain the important factors for selecting suitable materials for different AM processes. (6 marks)

OR

16 a. Describe the different material forms used in additive manufacturing (filament, powder, and liquid) and explain how they influence the printing process (8 marks)

b. Explain the metal materials used in additive manufacturing**,** focusing on Titanium, Aluminum, and Stainless Steel, and discuss their advantages and limitations. (6 marks)

Module IV

17 a. Explain the basic concepts and digitization techniques used in additive manufacturing. (8 marks)

b. Describe the process of model reconstruction and its importance in creating accurate 3D printable models. (6 marks)

OR

18 a. Discuss the steps involved in CAD model preparation for additive manufacturing. (8 marks)

b. Explain part orientation and support generation in additive manufacturing and their effects on part quality and printing time. (6 marks)

Module V

19 a. Explain the concept of process–structure–property relationships in additive manufacturing with suitable examples. (8 marks)

b. Explain the causes and effects of defects, residual stresses, and distortion in 3D printed components. (6 marks)

OR

20 a. Explain the biomedical applications of 3D Printing. (8 marks)

b. Discuss about the benefits of Rapid prototyping. (6 marks)

B24ME4G26	FUNDAMENTALS OF COMPOSITE MATERIALS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces the fundamental principles and engineering applications of composite materials, with emphasis on their structure–property relationships and processing techniques. It covers the classification and characteristics of composites, the role of interfaces and bonding, and the various types of fiber reinforcements used to enhance material performance. The course further explores polymer, metal, and ceramic matrix composites, including their properties, manufacturing methods, and industrial applications. By integrating material science concepts with processing technologies, the course equips students with the knowledge required to select, design, and apply composite materials effectively in modern engineering systems.

Prerequisites

Nil

Course Outcomes

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

CO1	Explain the history of composites, and describe various matrices and reinforcements used in composite materials. (Cognitive Knowledge Level: Understand)
CO2	Explain the types of fibers/whiskers used in composites, and describe their structure, properties, applications, and manufacturing processes. (Cognitive Knowledge Level: Understand)
CO3	Apply the principles of polymer matrix composites, including their classification, properties, characteristics, applications, and manufacturing methods, in engineering design and problem-solving. (Cognitive Knowledge Level: Apply)
CO4	Apply the concepts of metal matrix composites, including classification, properties, characteristics, applications, and manufacturing methods, in design and problem-solving; and explain the role of alloys as matrices and the significance of intermetallics. (Cognitive Knowledge Level: Apply)
CO5	Apply the principles of ceramic matrix composites, including classification, properties, characteristics, applications, and manufacturing methods, in engineering design and problem-solving. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	1	–	–	–	–	–	–	–	–	1
CO2	2	1	–	–	–	–	–	–	–	–	1
CO3	3	2	3	1	2	–	–	–	–	1	1
CO4	3	2	3	1	2	–	–	–	–	1	1
CO5	3	2	3	1	2	–	–	–	–	1	1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test1(%Marks)	Test2(%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	3hours

Continuous Internal Evaluation Pattern

Attendance :10 marks
Continuous Assessment Test (2numbers) :25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contain 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Introduction to Composites (7 hours)

Composite: Introduction, definition, characteristics, functions, classification of composites based on structure and matrix, smart composites, advantages and limitations, history, industrial scene and applications, Interfaces: wettability and bonding interface in composites. Types of bonding at the interface.

MODULE 2: Types of fibers/ whiskers used in composites (7 hours)

Fibers: Introduction, types of fibers, natural fibers, glass fiber fabrication, structure, properties and applications, boron fiber fabrication, structure, properties and applications, carbon fiber, Ex-Pan carbon fiber, Ex cellulose carbon fiber, Ex-Pitch carbon, carbon fiber structure, properties and applications, aramid fiber fabrication, structure, properties and applications, whiskers: characteristics, properties and applications.

MODULE 3: Polymer matrix composites (8 hours)

Polymer matrix composites (PMC): thermoset, thermoplastic and elastomeric polymers, properties, characteristics and applications as matrix materials, processing of polymer matrix composites: hand lay-up method, spray up method, moulding methods, pressure bagging and bag moulding methods, Autoclave-based processing with prepregs, pultrusion and filament winding process.

MODULE 4: Metal matrix composites (7 hours)

Metal matrix composites (MMC): classification of metals, intermetallics, alloys and their potential role as matrices in composites, properties, characteristics and applications of metals as matrix materials, production techniques: powder metallurgy, diffusion bonding, melt stirring, squeeze casting, liquid infiltration under pressure, in situ process.

MODULE: Ceramic matrix composites and Micromechanics of composites (7 hours)

Ceramic matrix composites (CMC): classification of ceramics and their potential role as matrices, properties, characteristics and applications of ceramics as matrix materials, conventional techniques: cold pressing and sintering, hot pressing, reaction bonding, liquid infiltration, pultrusion. lanxide process, in situ chemical technique, sol-gel technique,

Text Books

1. K. K. Chawla, *Composite Materials: Science and Engineering*, Springer.
2. P K Mallicak, *Fiber-reinforced composites*, Monal Deklar Inc., New York.
3. Reddy J. N., *Mechanics of Composite Materials*, Selected Works of Nicholas J Pagano, Springer.
4. Robert M. Jones, *Mechanics of Composite Materials*, CRC Press.

Reference Books

1. F. L. Matthews and R. D Rawlings, *Composite Materials, Engineering and Sciences*, Chapman and Hall, London.
2. George Lubin. Van Nostrand, *Hand Book of Composites*, Reinhold Co.
3. Micael Hyer, *Stress Analysis of Fiber-Reinforced Composite Materials*, Tata McGrawHill.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Composite: Introduction, definition, characteristics, functions.	1
1.2	Classification of composites based on structure and matrix: History, industrial scene and applications.	2
1.3	Smart composites, advantages and limitations.	2
1.4	Interfaces: wettability and bonding interface in composites.	1
1.5	Types of bonding at the interface.	1
	Module 2	**7**
2.1	Fibers: Introduction, types of fibers, natural fibers.	1
2.2	Fiberization, stabilisation, carbonisation, graphitisation, glass fiber Fabrication, structure, properties and applications.	1
2.3	Boron fiber fabrication, structure, properties and applications.	1
2.4	Carbon fiber, Ex-Pan carbon fiber, Ex-Pitch carbon, Ex cellulose carbon Fiber.	2
2.5	Aramid fiber fabrication, structure, properties and applications.	1
2.6	Whiskers: characteristics, properties and applications.	1
	Module 3	**8**
3.1	Polymer matrix composites (PMC): thermoset, thermoplastic and Elastomeric polymers	1
3.2	Properties, characteristics and applications as matrix materials	1
3.3	Processing of polymer matrix composites: hand methods, lay-up method, spray-up method	2
3.4	Moulding methods, pressure bagging and bag moulding methods, Autoclave-based processing with prepregs	2
3.5	Pultrusion and filament winding process.	2
	Module 4	**7**
4.1	Classification of metals, inter-metallics, alloys and their potential role as matrices in composites	2
4.2	Properties, characteristics and applications of metals as matrix materials	1
4.3	Production techniques: powder metallurgy, diffusion bonding, and melt stirring	2
4.4	Squeeze casting, liquid infiltration under pressure, in-situ process.	2
	Module 5	**7**
5.1	Classification of ceramics and their potential role as matrices	1
5.2	Properties, characteristics and applications of ceramics as matrix materials	2
5.3	Conventional techniques: cold pressing and sintering, hot pressing, Reaction bonding, liquid infiltration, and pultrusion.	2
5.4	Lanxide process, in-situ chemical technique, sol-gel technique	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome1 (CO1):

1. Explain about history of evolution of composites.
2. Explain about the function of reinforcement and matrix in composite.
3. Discuss about smart composites.
4. Explain about wettability of composites.

Course Outcome 2 (CO2):

1. Compare between natural fibers and synthetic fibers.
2. With neat sketched explain Ex-cellulose carbon fiber.
3. Explain whiskers with examples.
4. Explain Ex-Pan carbon fiber and Ex-Pitch carbon fiber fabrication.

Course Outcome 3 (CO3):

1. Discuss about thermoset, thermoplastic and elastomeric polymeric materials.
2. Explain different hand lay methods.
3. Explain different moulding methods for PMC.
4. Explain the characteristics and applications of polymer matrix materials.

Course Outcome 4 (CO4):

1. How are metal matrix composites classified?
2. Explain the role of intermetallics in MMC.
3. Explain the properties, characteristics and applications of MMC.
4. Explain the different production techniques of MMC.

Course Outcome 5 (CO5):

1. How CMC are classified and their potential role as matrix materials.
2. What are the properties, characteristics and applications of CMC.
3. Explain conventional techniques for the production of CMC.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.:.....

Name:.....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4G26**

Course Name: **FUNDAMENTALS OF COMPOSITE MATERIALS**

Max. Marks:100 Duration:3 hours

PARTA

Answer all questions. Each question carries 3 marks.

1		What do you mean by smart composite?
2		What are the conditions to be satisfied for a material to be called as a composite material?
3		Compare natural fibers and synthetic fibers.
4		Discuss about aramid fiber fabrication.
5		Distinguish thermoset and thermoplastic materials.
6		List the functions of components in pultrusion technique used in PMCs.
7		Name the metals and their properties used in metal matrix composites.
8		How metal matrix composites are classified.
9		What are the different failure modes of fiber composites?
10		Explain lanxide process with a neat sketch.

PARTB

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

Module 1

11	a.	What are the major constituents of a composite material? Explain the significance of each.	(6 marks)
	b.	Explain different types of bonding at interface region in composites.	(8 Marks)

OR

12 a. What are the conditions to be satisfied for a material to be called as a composite material? (7 Marks)

b. Briefly explain the various applications of composite materials. (7 Marks)

Module 2

13 a. Explain the classification of composites based on the length of the fibers and give the significance of each. (7 Marks)

b. Explain boron fiber fabrication with a neat sketch. (7 Marks)

OR

14 a. What are carbon fibers? Give the various applications of carbon fiber. (6 Marks)

b. Classify various types of fibers used in composite materials. (8 Marks)

Module 3

15 a. Explain the significance of various polymer materials used for PMC production. (9 Marks)

b. List out the various production processes for PMCs (5 Marks)

OR

16 a. Give brief comparison on thermosets and thermoplastics. (6 Marks)

b. Explain filament winding process with a neat sketch. (8 Marks)

Module 4

17 a. Explain the advantages and disadvantages of Metal Matrix Composites. (6 Marks)

b. Describe the squeeze casting method for MMC production with a neat figure. (8Marks)

OR

18 a. What are the advantages and disadvantages of using liquid state processes in making metal matrix composites? (6 marks)

b. Explain various solid-state production processes for Metal Matrix Composites. (8 Marks)

Module 5

19 a. What are ceramics? Explain the significance of ceramic matrix composites. (6 Marks)

b. Explain the slurry infiltration process for ceramic matrix composites with a neat figure. (8 Marks)

OR

20 a. Discuss the benefits of the reaction bonding process of CMCs. (6 Marks)

b. Discuss the lanxide process for the fabrication of ceramic matrix composites. (8 Marks)

B24ME4G27	INTRODUCTION TO ACOUSTICS AND NOISE CONTROL	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Introduction to acoustics and noise control is an open elective course designed to introduce students from all engineering disciplines to the fundamentals of sound, human hearing, noise measurement, and control techniques. This course covers the basic principles of acoustics, sound propagation, and room acoustics, along with the effects of noise on humans, machinery, and the environment. Advanced topics, including acoustic metamaterials, active noise control, and sustainable acoustic design, are also introduced to expose students to modern approaches in industrial, environmental, and architectural acoustics. The course aims to equip students with the skills to understand, evaluate, and mitigate noise and vibration in practical engineering systems.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain fundamental acoustic concepts such as wave propagation, sound parameters, and acoustic measurements. (Cognitive Knowledge Level: Understand)
CO 2	Apply sound propagation principles to evaluate acoustic behavior in indoor and outdoor environments. (Cognitive Knowledge Level: Apply)
CO 3	Describe the human hearing mechanism and explain the effects of noise on health and environment. (Cognitive Knowledge Level: Understand)
CO 4	Apply noise measurement instruments and techniques to determine and interpret sound levels. (Cognitive Knowledge Level: Apply)
CO 5	Apply noise control methods and acoustic materials to reduce noise and vibration in engineering systems. (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	-	-	-	-	-	-	-	-	1
CO 2	3	3	2	-	-	1	-	-	-	-	-
CO 3	2	2	-	-	-	3	2	-	-	-	-
CO 4	2	3	-	3	3	-	-	-	-	-	-
CO 5	2	2	3	2	2	3	1	-	-	-	1

Assessment Pattern

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

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Fundamentals of Acoustics (7 hours)

Introduction, nature of sound, sound waves, frequency, wavelength, speed of sound, sound pressure, particle velocity, acoustic velocity, acoustic wave equation, harmonic solution.
Plane acoustic waves, harmonic waves, acoustic impedance, sound power, sound intensity, energy density, decibel scale, sound pressure level, sound intensity level, sound power level.

MODULE 2: Sound Propagation and Room Acoustics (7 hours)

Sound propagation, reflection of sound, absorption of sound, transmission of sound, diffraction of sound, environmental noise sources, outdoor sound propagation.
Room acoustics, reverberation, reverberation time, echo, flutter echo, sound insulation, transmission loss, standing waves, acoustic design of rooms, auditorium acoustics.

MODULE 3: Human Hearing and Noise Effects (7 hours)

Human ear structure, hearing mechanism, hearing range, hearing threshold, loudness perception, phon scale, sone scale, perceived noise level.
Speech interference level, noise induced hearing loss, physiological effects of noise, psychological effects of noise, occupational noise exposure, environmental noise standards.

MODULE 4: Noise Measurement and Analysis (7 hours)

Noise measurement principles, microphones, sound level meters, sound intensity probes, noise dosimeters, noise analyzers.
Graphic level recorders, frequency spectrum analysis, octave band analysis, environmental noise measurement, anechoic chambers, reverberation chambers.

MODULE 5: Noise Control Engineering and Advanced Acoustic Materials (8 hours)

Principles of noise control, source control, path control, receiver protection, acoustic enclosures, noise barriers, silencers, mufflers, acoustic insulation, sound absorbing materials, active noise control, vibration isolation.
Advanced acoustic materials, acoustic metamaterials, locally resonant structures, phononic crystals, 3D printed acoustic materials, applications in noise reduction, smart noise control systems, green acoustics, sustainable acoustic design.

Text Books

1. D. A. Bies and C. H. Hansen, *Engineering Noise Control: Theory and Practice*, CRC Press.
2. L. E. Kinsler, A. R. Frey, A. B. Coppens, & J. V. Sanders, *Fundamentals of Acoustics*, Wiley.
3. I. L. Vér and L. L. Beranek, *Noise and Vibration Control Engineering*, Wiley.
4. B. P. Lathi and R. Srinivasan, *Sound and Vibration Measurement Techniques*, McGraw-Hill.

Reference Books

1. M. J. Crocker, *Handbook of Noise and Vibration Control*, John Wiley & Sons, Inc.
2. H. Kuttruff, *Acoustics: An Introduction*, Taylor & Francis.
3. T. D. Rossing and N. H. Fletcher, *Green and Sustainable Acoustics*, Springer.
4. M. Moser, *Engineering Acoustics*, Springer.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Introduction, nature of sound, sound waves	1
1.2	Frequency, wavelength, speed of sound	1
1.3	Sound pressure, particle velocity, acoustic velocity	1
1.4	Acoustic wave equation, harmonic solution	1
1.5	Plane acoustic waves, harmonic waves, acoustic impedance	1
1.6	Sound power, sound intensity, energy density, decibel scale	1
1.7	Sound pressure level, sound intensity level, sound power level	1
	Module 2	**7**
2.1	Sound propagation, reflection of sound, absorption of sound	1
2.2	Transmission of sound, diffraction of sound	1
2.3	Environmental noise sources, outdoor sound propagation	1
2.4	Room acoustics, reverberation, reverberation time	1
2.5	Echo, flutter echo, sound insulation	1
2.6	Transmission loss, standing waves	1
2.7	Acoustic design of rooms, auditorium acoustics	1
	Module 3	**7**
3.1	Human ear structure, hearing mechanism, hearing range	1
3.2	Hearing threshold, loudness perception, phon scale	2
3.3	Sone scale, perceived noise level	1
3.4	Speech interference level, noise induced hearing loss	1
3.5	Physiological effects of noise, psychological effects of noise	1
3.6	Occupational noise exposure, environmental noise standards	1
	Module 4	**7**
4.1	Noise measurement principles, microphones	1
4.2	Sound level meters, sound intensity probes	1
4.3	Noise dosimeters, noise analyzers	1
4.4	Graphic level recorders, frequency spectrum analysis	1
4.5	Octave band analysis	1
4.6	Environmental noise measurement	1
4.7	Anechoic chambers, reverberation chambers	1
	Module 5	**8**
5.1	Principles of noise control, source control, path control	1
5.2	Receiver protection, acoustic enclosures, noise barriers	1
5.3	Silencers, mufflers, acoustic insulation	1
5.4	Sound absorbing materials, active noise control, vibration isolation	1
5.5	Advanced acoustic materials	1
5.6	Acoustic metamaterials, locally resonant structures	1
5.7	Phononic crystals, 3D printed acoustic materials	1
5.8	Applications in noise reduction, smart noise control systems, green acoustics, sustainable acoustic design	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the fundamental acoustic quantities such as sound pressure, particle velocity, acoustic velocity, and acoustic impedance.
2. Derive the acoustic wave equation for a plane sound wave.
3. a. Discuss about different 'levels' of sound measurement
   b. A harmonic plane wave is propagating with frequency 35 Hz in air at room temperature. The acoustic pressure at a point 1.5 m from the sound source at a time 2 s from the instant of observation is 0.2 Pa. Find the acoustic pressure at the same point at 4 s.

Course Outcome 2 (CO2):

1. Describe about spherical waves, beam width and directivity index.
2. Sound wave is propagating from a fluid medium of density ρ_1 to a fluid medium of density ρ_2 at an angle of incidence θ_1. The speed of sound in first medium is C_1 and that in second medium is C_2. Obtain the pressure reflection and pressure transmission coefficient.
3. Define standing waves and explain how they are formed.

Course Outcome 3 (CO3):

1. With the help of a neat sketch explain the hearing mechanism in human beings.
2. Discuss the concepts of phon scale, sone scale, and perceived noise level, and explain their significance in evaluating human response to sound.
3. Describe about any two noise standards.

Course Outcome 4 (CO4):

1. 1 Explain the principles of noise measurement.
2. a) Explain about the working of noise analyzer.
   b) What are microphones?
3. How sound is measured in a reverberation chamber and in an anechoic chamber?

Course Outcome 5 (CO5)

1. Explain about absorption coefficient. What are acoustic absorbers?
2. A machine produces a noise level of 100 dB. After installing a noise barrier that provides a transmission loss of 20 dB, determine the resulting noise level at the receiver and comment on the effectiveness of the control method.
3. Explain the working principles of advanced acoustic materials.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4G27**

Course Name: **INTRODUCTION TO ACOUSTICS AND NOISE CONTROL**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Define sound pressure and particle velocity.

2 Define acoustic impedance and state its importance in acoustics.

3 What is directivity index? Explain its significance in sound radiation.

4 Define standing waves and explain how they are formed.

5 Define hearing threshold and explain its importance in acoustics.

6 What are noise criteria (NC) curves and why are they used?

7 What is a microphone? Mention its role in acoustic measurements.

8 What is an anechoic chamber and state its purpose.

9 List any three methods used for noise control at the source in machinery.

10 Define active noise control and mention any two practical applications.

PART B

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

Module 1

11 a. Derive acoustic wave equation. Deduce the equation for plane acoustic wave. (10 Marks)

b. A harmonic plane wave is propagating with frequency 35 Hz in air at room temperature. The acoustic pressure at a point 1.5 m from the sound source at a time 2s from the instant of observation is 0.2 Pa. Find the acoustic pressure at the same point at 4 s. (4 Marks)

OR

12 a. Explain sound power, sound intensity, and energy density. Discuss their interrelationship in sound propagation. (10 Marks)

b. The sound intensity at a point is 1×10^{-4} W/m². Calculate the sound intensity level in decibels. (4 Marks)

Module 2

13 a. Discuss spherical waves, hemispherical sources, and radiating piston with suitable diagrams. (10 Marks)

b. A point sound source emits acoustic power of 0.5 W. Determine the sound intensity at a distance of 4m from the source assuming spherical spreading. (4 Marks)

OR

14 Describe the formation of standing waves in pipes and explain the working principle of a standing wave apparatus used in acoustic measurements. (14 Marks)

Module 3

15 a. With suitable figure, explain the hearing mechanism in human ear. (8 Marks)

b. Explain the concepts of loudness, phon scale, and sone scale. (6 Marks)

OR

16 Explain the concept of speech interference level (SIL). Describe the noise criteria (NC) curves and explain how they are used to evaluate acceptable noise levels in buildings and industrial environments. (14 Marks)

Module 4

17 a. Explain the construction and working principle of microphones used in noise measurement. Discuss different types of microphones. (10 Marks)

b. Describe the working principle of a sound level meter. (4 Marks)

OR

18 Explain the concept of frequency spectrum analysis and octave band analysis in noise measurement. (14 Marks)

Module 5

19 Discuss the design and application of acoustic enclosures, silencers, and mufflers used to reduce noise in machines. Explain the selection criteria and effectiveness. (14 Marks)

OR

20 Compare the noise attenuation mechanisms of phononic crystals and locally resonant acoustic metamaterials (LRAMs). Explain why LRAMs are often preferred for low-frequency "Green" building applications where space is a constraint. (14 Marks)

B24HU4T04	DISASTER MANAGEMENT AND INDUSTRIAL SAFETY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Disasters and industrial accidents can significantly impact human life, infrastructure, industries, and the environment. Engineers play a vital role in preventing hazards, ensuring workplace safety, and supporting disaster preparedness and response. This course introduces the fundamentals of disaster management and industrial safety, covering disaster risk reduction, emergency response, hazard identification, safety practices, statutory requirements, and environmental safety. The course enables students to understand safety challenges in industrial and societal contexts and develop awareness of risk management and preventive strategies for creating safer and more resilient communities and workplaces.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the fundamental concepts, classifications, and phases of the disaster management cycle and their impacts on society. (Cognitive Knowledge Level: Understand)
CO 2	Apply risk analysis concepts to identify and predict hazards at various administrative levels. (Cognitive Knowledge Level: Apply)
CO 3	Apply hazard identification techniques such as HAZOP and FMEA to assess industrial risks and accident causes. (Cognitive Knowledge Level: Apply)
CO 4	Explain industrial safety standards, fire safety protocols, and statutory provisions related to workplace safety. (Cognitive Knowledge Level: Understand)
CO 5	Apply lessons learned from major industrial and environmental disasters to promote safe and sustainable practices. (Cognitive Knowledge Level: Apply)

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	30	30	30
Understand	40	40	30
Apply	30	30	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

KNOWLEDGE IS POWER

SYLLABUS

Module 1: Introduction to Disaster Management (8 hours)

Disaster: definition, scope, and importance. Classification of disasters: natural and man-made. Natural disasters: earthquake, flood, cyclone, drought, landslide, tsunami – causes and effects. Man-made disasters: industrial accidents, chemical disasters, nuclear disasters, fire hazards – Impacts of disasters on human life, infrastructure, economy, and environment. Disaster management cycle: prevention, mitigation, preparedness, response, recovery.

Module 2: Disaster Preparedness, Mitigation, and Response (8 hours)

Disaster risk reduction concepts. Hazard, vulnerability, and risk analysis. Disaster preparedness planning at community, district, state, and national levels. Early warning systems and forecasting methods. Emergency response planning, evacuation procedures, and shelter management. Role of government agencies (NDMA, SDMA, DDMA),

Module 3: Industrial Safety and Hazard Identification (7 Hours)

Introduction to industrial safety and accident prevention. Types of industrial hazards: mechanical, electrical, chemical, biological, radiation, ergonomic. Causes of industrial accidents and accident causation theories. Hazard identification techniques: HAZOP, FMEA. Safety management systems and safety culture. Risk assessment and control measures.

Module 4: Industrial Safety Practices and Legislation (7 Hours)

Safety legislation and statutory provisions – Hearing Conservation Programme**:** Principles, implementation and monitoring. Fire safety: causes of fire, fire prevention, detection, and fire-fighting systems – Electrical safety and machine guarding – Personal Protective Equipment (PPE): types, selection, and usage.

Module 5: Environmental Safety, Case Studies (6 Hours)

Environmental pollution due to industrial activities – Solid, liquid, and hazardous waste management – Sustainable industrial safety practices – Case studies: Bhopal Gas Tragedy, Chernobyl Nuclear Disaster, Fukushima Disaster – Lessons learned and preventive strategies.

Text Books

1. Harsh K. Gupta, *Disaster Management*, Universities Press (Orient Black swan), 2003.
2. John R. Jensen*, Remote Sensing of the Environment: An Earth Resource Perspective*, Pearson Prentice Hall, Upper Saddle River, NJ.
3. K. U. Mistry*, Fundamentals of Industrial Safety and Health (Vol. 1 & 2),* Siddharth Prakashan.

References

1. Harsh K. Gupta, *Disaster Management*, Universities Press.
2. Thomas M. Lillesand, Ralph W. Kiefer, Jonathan W. Chipman, *Remote Sensing and Image Interpretation*, Wiley.
3. R. K. Jain, Sunil S. Rao, *Industrial Safety, Health and Environment Management Systems*, Khanna Publishers.
4. Roger L. Brauer, *Safety and Health for Engineers*, Wiley.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	MODULE 1	**8**
1.1	Disaster definition, scope, and importance. Classification of disasters. 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	**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	**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	**7**
4.1	Safety Legislation & Statutory Provisions Hearing Conservation Programme	2
4.2	Fire Safety Fundamentals.	1
4.3	Fire-Fighting Systems and Electrical Safety	2
4.4	Machine Guarding & Personal Protective Equipment (PPE)	2
	MODULE 5	**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	Lessons learned and preventive strategies.	1
	Total	**36 hours**

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 Risk = Hazard × Vulnerability, explain how you would identify high-risk zones and prioritize mitigation measures at community and district levels.
2. Explain spatial, spectral, temporal, and radiometric resolutions in remote sensing. For each, mention one disaster-management application (flood/cyclone/landslide monitoring).

Course Outcome 3 (CO 3):

1. In a chemical storage facility, outline the steps to perform a HAZOP study and demonstrate how deviations (e.g., “more pressure”, “less flow”) can lead to accident scenarios.
2. Perform an FMEA framework for an industrial system (any one: boiler, conveyor belt, electrical panel, solvent storage tank): identify failure modes, effects, severity/occurrence/detection, and suggest controls.

Course Outcome 4 (CO 4):

1. Discuss key provisions of the Factories Act related to safety, health, and welfare. Explain how statutory compliance improves industrial safety performance.
2. For an industrial workshop/lab building, prepare a fire safety and electrical safety plan covering fire triangle, detection & suppression systems, safe evacuation, LOTO concept, and machine guarding.

Course Outcome 5 (CO 5):

1. Compare the engineering and governance lessons learned from any two case studies: Bhopal Gas Tragedy, Chernobyl, Fukushima. Focus on root causes, systemic failures, and preventable gaps.
2. As a consulting engineer, propose a sustainable disaster prevention strategy for an industrial township (or campus): include ethical responsibilities, waste/pollution control, emergency preparedness, and “build back better” principles.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No. : .....

Name : .....

MAR ATHANASIUS 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.

Module 1

11 a. Explain the causes and effects of any two natural disasters. (7 marks)

b. Explain the Disaster Management Cycle and describe how each phase reduces impacts. (7 marks)

OR

12 a. Explain man-made disasters with reference to industrial accidents/chemical/ nuclear/ fire hazards—causes and impacts. (7 marks)

b. Explain spatial, spectral, temporal, and radiometric resolutions and mention one application of each in disaster studies. (7 marks)

Module 2

13 a. Explain Disaster Risk Reduction (DRR) and describe risk analysis using hazard–vulnerability concepts. (7 marks)

b. Prepare a community-level disaster preparedness plan (key components and steps). (7 marks)

OR

14 a. Explain early warning systems and forecasting methods for any one hazard. (7 marks)

b. Describe evacuation procedures and shelter management for a district-level emergency. (7 marks)

Module 3

15 a. Explain accident causation theories and discuss common causes of industrial accidents. (7 marks)

b. Explain safety management system and elements of safety culture with suitable measures. (7 marks)

OR

16 a. Conduct a HAZOP outline for a chemical storage/processing unit: nodes, deviations, causes, consequences, safeguards. (7 marks)

b. Prepare an FMEA for an industrial system (any one: electrical panel/boiler/conveyor/solvent tank): failure modes, effects, and controls. (7 marks)

Module 4

17 a. Discuss major Factories Act provisions for safety, health, and welfare with examples. (7 marks)

b. Explain OSHA principles and how they improve workplace safety performance. (7 marks)

OR

18 a. Explain fire detection and fire-fighting systems (alarms, extinguishers, hydrants/sprinklers) and a basic emergency plan. (7 marks)

b. Explain electrical safety and machine guarding, and discuss PPE types, selection, and correct usage. (7 marks)

Module 5

19 a. Explain industrial pollution pathways and describe solid, liquid and hazardous waste management practices. (7 marks)

b. Explain sustainable industrial safety practices and the ethical role of engineers in prevention. (7 marks)

OR

20 a. Write a case study on Bhopal / Chernobyl / Fukushima (any one): causes, failures, impacts. (7 marks)

b. List lessons learned and preventive strategies (engineering + management) to avoid recurrence and support “build back better”. (7 marks)

B24ME4L10	ADVANCED MECHANICAL ENGINEERING LAB	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		0	0	3	2	2	2024

Preamble

This laboratory course provides hands-on exposure to key concepts in machine dynamics, measurement of cutting forces in milling operations, and the fundamentals of pneumatic and hydraulic systems. It also introduces students to stepper motors, data acquisition systems, and basic automation, enabling them to develop practical skills relevant to modern manufacturing and control applications.

Prerequisite

Nil

Course Outcomes

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

CO 1	Apply practical skills to design and analyze mechanisms in machines. (Cognitive Knowledge Level: Apply)
CO 2	Measure and evaluate cutting forces in milling machining operations. (Cognitive Knowledge Level: Apply)
CO 3	Apply the principles of hydraulic and pneumatic actuators in product and process applications. (Cognitive Knowledge Level: Apply)
CO 4	Analyze and utilize data acquisition and control systems for products and processes. (Cognitive Knowledge Level: Analyse)
CO 5	Develop CNC programs and analyze measurement data using Coordinate Measuring Machines (CMM). (Cognitive Knowledge Level: Analyse)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	3	2	2	1	2	–	–	–	–	–	–
CO 2	3	2	–	2	2	–	–	–	–	–	–
CO 3	3	1	2	–	2	–	–	–	–	–	–
CO 4	2	3	1	3	3	–	–	–	–	–	1
CO 5	2	3	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 Evaluation
- Class work/ Assessment : 10 marks
- Viva (Self Study) : 10 marks

Viva voce / Test : 15 marks
Record : 5 marks

End Semester Examination Pattern

Experiment part : 70 marks
Viva voce : 30 marks

Guidelines for award of marks for the experiment part:

Preliminary work : 15 Marks
Implementing the work/Conducting the experiment : 25 Marks
Performance, result and inference : 30 Marks

SYLLABUS

LIST OF EXPERIMENTS

Minimum **10** experiments are mandatory (Including study)

1	Experiment on the Whirling of the shaft.
2	Experiment on Gyroscope.
3	Experiment on the Universal governor apparatus.
4	Experiment on Free vibration analysis.
5	Experiment on Forced Vibration Analysis.
6	Fabrication of Glass Fiber Composite Laminate using hand layup process and evaluation of Mechanical Properties.
7	Fabrication of Glass Fiber Composite Laminate using vacuum bag molding process and evaluation of Mechanical Properties.
8	Experiment on non-destructive test - Calibration of electromagnetic yoke for NDT testing (Dry and wet methods)
9	Experiment on non-destructive test -Study on liquid penetrant inspection type NDT testing
10	Exercises on pneumatic circuits using the pneumatic trainer unit.
11	Exercises on hydraulic circuits using a hydraulic trainer unit.
12	Exercises on electro-pneumatic and electro-hydraulic circuits using trainer units.
13	Exercises on 3-D printing.
14	Exercises on the motion controller using AC/DC motor, servo motors and encoders to determine the operating characteristics.
15	Exercises on the stepper motor to determine the operating characteristics.
16	Exercises on PC based data acquisition system with any software.
17	Study and preparation of programme, simulation and exercise on CNC lathe:- turning, step turning, taper turning, thread cutting, ball and cup turning etc.
18	Study and preparation of programme, simulation and exercise on CNC milling machine: - surface milling, pocket milling, contour milling etc.

Reference Books

1. C. E. Wilson, P. Sadler, *Kinematics and Dynamics of Machinery*, Pearson Education.
2. D. H. Myskza, *Machines and Mechanisms Applied Kinematic Analysis*, Pearson Education.
3. W. Bolton, *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering,* Person Education Limited, New Delhi.
4. K. P. Ramachandran, G. K. Vijayaraghavan, M. S. Balasundaram, *Mechatronics: Integrated Mechanical Electronic Systems,* Wiley India Pvt. Ltd., New Delhi.
5. Serope Kalpakjian, Steven R. Schmid - *Manufacturing Engineering and Technology*, Pearson

B24ME4L11	PROJECT PHASE I	Category: PWS	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.

Prerequisites

Nil

Course Objectives

- To apply engineering knowledge in practical problem-solving.
- To foster innovation in design of products, processes, or systems with consideration for sustainability.
- To develop creative thinking in finding viable, ethical, and socially relevant solutions to engineering problems.

Course Outcomes [COs] (After successful completion, students will be able to):

CO1	Apply engineering knowledge across domains to model, analyze, and solve real-world problems through practical design, simulation, or prototyping. (Cognitive Knowledge Level: Apply)
CO2	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)
CO3	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)
CO4	Plan, schedule, and execute project tasks efficiently using available resources, within timelines, while adhering to ethical, professional, and budgetary norms. (Cognitive Knowledge Level: Apply)
CO5	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

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

SDG Relevance — Projects should align with UN SDGs (e.g., SDG 9 for innovation/infrastructure, SDG 7/13 for clean energy/climate, SDG 11 for sustainable communities, SDG 3/6 for health/water, etc.), especially in CO2 and problem definition.

Phase 1 Targets (unchanged core, minor emphasis on sustainability/ethics):

- Literature study/survey.
- Formulation of objectives.
- Formulation of hypothesis/design/methodology.
- Work plan and task allocation.
- Block-level design documentation.
- Seeking project funds.
- Preliminary analysis/modeling/simulation/experiment/design/feasibility study/prototype.
- Preparation of Phase 1 report.

Evaluation Guidelines & Rubrics Total: **100 marks** (Minimum to pass: 50).

- Project progress evaluation by guide: **30** Marks.
- Interim evaluation by Evaluation Committee: **30** Marks.
- Final Evaluation by Evaluation Committee: **30** Marks.
- Project Phase-I Report (by Evaluation Committee): **10** Marks.

(The Evaluation Committee comprises of HoD/Senior faculty, Project Coordinator, and Supervisor.)

Evaluation by the Guide (30 Marks)

Sl. No.	Parameters	Marks	Poor (0-3)	Fair (4-6)	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.

Sl. No.	Parameters	Marks	Poor (0-3)	Fair (4-6)	Very Good (7-9)	Outstanding (10)
1-b	Project Planning, Scheduling, Resource/Tasks Identification & Allocation (Group) **[CO4]**	15	No evidence of planning/scheduling/budget; poor task allocation.	Some primary plan; incomplete schedules/journal.	Good planning; schedules prepared; better allocation.	Excellent planning; Gantt charts/modern tools; detailed budget; well-kept journal; clear individual tasks.

Interim Evaluation (30 Marks - Group mostly)

Sl. No.	Parameters	Marks	Poor (0-3)	Fair (4-6)	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)

Sl. No.	Parameters	Marks	Poor (0-3)	Fair (4-6)	Very Good (7-9)	Outstanding (10)
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.

Sl. No.	Parameters	Marks	Poor (0-3)	Fair (4-6)	Very Good (7-9)	Outstanding (10)
1-e	Preliminary Analysis/Modeling/ Simulation/Experiment/Design/Feasibility (Group) **[CO1/CO2]**	10	No preliminary work.	Started but not thorough.	Good evidence; can improve.	Strong/excellent work; poised for strong completion; shows innovation/sustainability aspects.
1-f	Documentation & Presentation (Group/Individual) **[CO5]**	5	Poor/no documentation/ presentation.	Some but incomplete.	Good; needs improvement.	Professional (e.g., LaTeX); excellent structure/presentation; clear communication of findings.

Project Phase-I Report (10 marks)

Sl. No.	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

1. Team size: Preferably 4 members (Maximum 5 members) (Preferably from same batch unless for interdisciplinary projects).
2. For the project, identify one base paper publication. It should be from IEEE, Elsevier, ACM journal, Science Citation Index (SCI) journal or a good Scopus Indexed journal. Conference papers are not permitted. Only recently published papers are allowed.
3. For the literature survey at least 10 publications are to be reviewed.
4. Try to get funding from agencies like KSCSTE, CERD, etc. Projects that can benefit society have more probability of attracting funding and prizes.
5. Every student must keep their own project diary. It should be a in the prescribed format. Record all details related to the project with dates. Every week, you must show the project diary to your project guide and get a signature (Or email approval if classes are handled in online mode). You will be asked to submit the project diaries periodically.
6. At the end of the Seventh semester, a project report has to be prepared in the prescribed format.
7. Proceed with project work, keeping in mind that preferably you need to publish one paper during the eighth semester.

B24ME4L12	SEMINAR	Category: PWS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
			0	0	4	1	2	2024

Preamble:

The course 'Seminar' enables engineering undergraduates to search, read, comprehend, present, and report on academic/technical documents (e.g., peer-reviewed journals, conferences, books, theses, project reports). Students select a topic/paper in consultation with their guide, preferably linked to their final-year project area or emerging technologies with relevance to sustainable development. This fosters literature survey skills, presentation abilities, technical reporting, and awareness of broader societal/environmental impacts (aligned with SDGs like SDG 4: Quality Education, SDG 9: Industry/Innovation/Infrastructure, and SDG 13: Climate Action where applicable).

Course Objectives:

- Conduct literature survey in a selected engineering area of interest.
- Understand and analyze academic/technical documents from peer-reviewed sources.
- Prepare and deliver an effective presentation on the selected document/topic.
- Prepare a comprehensive technical report with accurate references and consideration for sustainability/ethics where relevant.

Course Outcomes

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

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

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

General Guidelines

- Department forms Internal Evaluation Committee (IEC): Academic coordinator (Chairperson), Seminar coordinator, and guide(s) as members. All IEC members present during presentations.
- IEC formation and guide allotment within one week after previous semester exams/end.
- Guide assists in topic/paper selection (current, broad-based; preferably linked to final-year project; consider SDG relevance where possible).
- Student selects topic/paper during semester break; finalize/submit to IEC in Week 1; IEC approves by Week 2.
- Accurate references from genuine peer-reviewed sources required (verified in report).
- Maintain seminar diary for weekly progress monitoring by guide.

Evaluation Pattern

Total marks: 100 (CIE only, minimum required to pass: 50)

1. Seminar Guide: 20 marks

- **Background Knowledge** (10 marks): Assessed by the guide based on the student's depth of understanding demonstrated during weekly interactions, discussions, and diary entries.
- **Relevance of Topic/Paper Selected** (10 marks): Alignment with discipline, currency, breadth, linkage to final-year project/SDGs (if applicable), and justification.

Rubric for Background Knowledge (10 marks) – Guide awards holistically or averages sub-criteria.

Level	Score	Descriptor
Excellent	9–10	Demonstrates exceptional grasp; explains concepts deeply, handles advanced questions confidently, shows critical insight beyond the paper.
Good	7–8	Solid understanding; explains key ideas clearly, answers most questions accurately, shows good analysis.
Satisfactory	5–6	Basic understanding; explains main points but with gaps, answers simple questions, limited depth.
Unsatisfactory	0–4	Poor/limited knowledge; struggles to explain basics, major misconceptions evident.

Rubric for Relevance of Topic/Paper (10 marks)

Level	Score	Descriptor
Excellent	9–10	Highly relevant, current/emerging topic; strong linkage to discipline/project/SDG; broad yet focused; peer-reviewed sources premium.
Good	7–8	Relevant and current; good project/SDG linkage; appropriate breadth.
Satisfactory	5–6	Moderately relevant; some linkage but narrow/specific or outdated.
Unsatisfactory	0–4	Low relevance; no clear linkage, outdated, or non-peer-reviewed dominant.

2. Seminar Coordinator: 20 marks

- **Seminar Diary** (10 marks): Weekly progress entries, guide approvals, regularity.
- **Attendance** (10 marks)

Rubric for Seminar Diary (10 marks)

Level	Score	Descriptor
Excellent	9–10	Complete, detailed weekly entries; clear progress milestones; insightful reflections; all approvals timely.
Good	7–8	Regular entries with good detail; most milestones tracked; approvals mostly on time.
Satisfactory	5–6	Basic entries; some gaps in detail/progress; approvals irregular.
Unsatisfactory	0–4	Incomplete/sparse entries; major gaps; few approvals.

3. Presentation: 40 marks (Awarded by IEC – all members)

Analytic rubric applied during the presentation session.

Criterion	Weight	Excellent (4)– 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 ±10%).	Clear and well-structured, good delivery, minor timing issues.	Moderately clear, some disorganization, delivery fair, timing off.	Unclear, poor flow, mumbled delivery, major timing overrun/underrun.
Interactions / Q&A (Ability to answer questions, defend concepts, depth)	10	Confident, accurate, insightful answers; handles complex questions effectively.	Good answers to most questions; some depth shown.	Basic answers; struggles with follow-ups.	Poor/inaccurate answers; unable to defend key points.

Criterion	Weight	Excellent (4)– Full marks scaled	Good (3)	Satisfactory (2)	Unsatisfactory (1)
Overall Participation (Involvement in peers' sessions – questions asked, feedback given)	10	Highly active; insightful questions/feedback in most sessions.	Active; contributes meaningfully in several sessions.	Minimal participation; occasional questions.	Little/no involvement in others' sessions.
Quality of Slides (Visual appeal, content organization, technical accuracy, references, minimal text)	10	Outstanding design; error-free, well-organized, excellent visuals/references.	Good design; minor errors, clear organization.	Adequate but cluttered/average visuals.	Poor design; many errors, overcrowded, missing references.

4. Report: 20 marks (Awarded by IEC)

Analytic rubric for the final technical report.

Criterion	Weight	Excellent (4) – 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.
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.

B24ME4T02	VIVA VOCE	Category: PWS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
			0	0	0	0	1	2024

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 basic to advanced concepts, problem-solving, derivations, applications, and interconnections between subjects.

Conduct of Viva:

Conducted by a panel (Internal examiner from the department, with HoD/senior faculty). Duration: 15–30 minutes per student (individual). May include follow-up questions, blackboard explanations, or simple derivations.

Evaluation Pattern

Total: 100 Marks (100% Continuous Internal Evaluation (CIE)).

No End Semester Examination (ESE).

Minimum pass: 50 marks out of 100.

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.

Parameter	Marks	Poor (0–10)	Fair (11–20)	Good (21–30)	Very Good (31–40)	Excellent/ Outstanding (41–50)
Understanding & Application (Ability to apply concepts, solve simple problems, explain real-world relevance, interconnections)	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.
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**					

Guidelines for Preparation & Conduct

- Students should revise **all core theory + lab courses** from S1 to S6.
- Focus on fundamentals and advanced topics.
- Viva is usually scheduled in the last 1–2 weeks of the 7th semester.
- No written component; purely oral (may include diagrams/derivations on board)

MAR ATHANASIUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution

Kothamangalam, Kerala, India

B.TECH MECHANICAL ENGINEERING

SEMESTER 7

(MINOR)

SYLLABUS

B24MEM71	DESIGN THINKING AND PRODUCT DEVELOPMENT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

The course on Design Thinking and Product Development aims to develop creativity and analytical skills for designing innovative, user-centered products. It introduces design thinking, agile practices, and product development frameworks, with emphasis on integrating engineering, sustainability, and business considerations to develop feasible and market-relevant solutions. It also encourages collaborative problem-solving and iterative learning to address real-world challenges effectively.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the fundamentals, principles, and stages of the design thinking process with a human-centered approach. (Cognitive Knowledge Level: Understand)
CO 2	Explain the principles and frameworks of Agile and DevOps in product development. (Cognitive Knowledge Level: Understand)
CO 3	Apply ideation, prioritization, and strategic innovation techniques to develop solution concepts. (Cognitive Knowledge Level: Apply)
CO 4	Apply customer-centric and sustainable design approaches for real-world problems. (Cognitive Knowledge Level: Apply)
CO 5	Apply product development frameworks, prototyping, and ethical considerations in design solutions. (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
CO1	3	2	2	–	–	–	–	–	–	–	–
CO2	2	2	2	–	2	–	–	–	1	1	1
CO3	2	3	3	1	2	–	1	–	2	1	1
CO4	2	3	2	1	–	1	3	2	–	–	–
CO5	2	2	3	2	2	1	2	3	2	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Foundations of Design Thinking (8 hours)

Foundations of Design Thinking: Design - Fundamentals, Design Thinking - Definition and core concepts, Human-centric design, Design thinking framework, Principles and characteristics of design thinking, design thinking process in depth. Case Studies.

MODULE 2: Introduction to Agile and DevOps (8 hours)

Introduction to Agile and DevOps: History of Agile, Evolution, Principles and values, Scrum framework, Kanban, DevOps - Principles, lifecycle and practices, CI/CD Processes and tools, Agile vs DevOps. Case Studies.

MODULE 3: Idea generation, Prioritization, and Strategic innovation (9 hours)

Idea generation, Prioritization, and Strategic innovation: Brainstorming, mind mapping, SCAMPER, and prioritization techniques. Innovation management, strategic innovation - linear vs non-linear, 3-Box thinking framework, linking design thinking to business. Case Studies.

MODULE 4: Customer-centric and Sustainable Designs (10 hours)

Customer-centric and Sustainable Designs: Enhancing customer experience, service design principles, service experience with case studies, industrial design aspects in products, Design for Environment (DFE) decisions, sustainable design considerations for product life cycle, green design, and circular economy. Case Studies.

MODULE 5: Innovative Product Development Frameworks and Ethical considerations (10 hours)

Innovative Product Development Frameworks and Ethical considerations: New Product Development (NPD) Processes and fuzzy front end (FFE), Product planning, Minimum viable product (MVP) development, Product value definition and measurement, differentiation and focus strategies in product design, prototyping and iterative testing, Ethical considerations.

Text Books

1. Srinivasan R, Mohammed Ismail & Arulmozhi Srinivasan, *A Textbook on Design Thinking: Principles, Processes and Applications*, S Chand Publishing, 2025.
2. Larry Leifer, Christoph Meinel, Hasso Plattner, *Design Thinking: Understand – Improve – Apply*, Springer, 2011.
3. E. Balagurusamy, *Design Thinking*, McGraw Hill Education, 2021.

Reference Books

1. Ilpo Koskinen, *Design, Empathy, Interpretation: Toward Interpretive Design Research*, The MIT Press.
2. Thomas Binder, Giorgio De Michelis, Pelle Ehn, Giulio Jacucci, *Design Things*, The MIT Press.
3. Suresh Nair K. R., *Product Sense: Engineering Your Ideas into Reality*, Notion Press.
4. Chandramouli Subramanian, Thiyagarajan Paramasivan & Sankaran Venkataramani,

Design Thinking: A Hands-on Approach, Orient BlackSwan / Universities Press.

5. Tim Brown, *Change by Design, Revised and Updated: How Design Thinking Transforms Organizations and Inspires Innovation*, HarperCollins.
6. Thomas Lockwood and Edgar Papke, *Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School*, Wiley.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1: Foundations of Design Thinking	**8**
1.1	Design – Fundamentals Design Thinking - Definition and core concepts	2
1.2	Human-centric design, Design thinking framework	2
1.3	Principles and characteristics of design thinking, design thinking process in depth.	2
1.4	Case Studies	2
	Module 2: Introduction to Agile and DevOps	**8**
2.1	History of Agile, Evolution, Principles, and Values	2
2.2	Scrum framework, Kanban	2
2.3	DevOps - Principles, lifecycle, and practices, CI/CD Processes and tools, Agile vs DevOps.	2
2.4	Case Studies	2
	Module 3: Idea generation, Prioritization, and Strategic innovation	**9**
3.1	Brainstorming, mind mapping, 3-Box thinking framework	2
3.2	SCAMPER, and prioritization techniques.	2
3.3	Innovation management, strategic innovation - linear vs non-linear	2
3.4	Linking design thinking to business.	1
3.5	Case Studies	2
	Module 4: Customer-centric and Sustainable Designs	**10**
4.1	Enhancing customer experience, service design principles,	2
4.2	Service experience with case studies, Industrial design aspects in products	2
4.3	Design for Environment (DFE) decisions, sustainable design considerations for product life cycle,	2
4.4	Green design, and Circular economy.	2
4.5	Case Studies	2
	Module 5: Innovative Product Development Frameworks and Ethical considerations	**10**
5.1	New Product Development (NPD) Processes and fuzzy front end (FFE),	2
5.2	Product planning, Minimum viable product (MVP) development	2
5.3	Product value definition and measurement	2
5.4	Differentiation and focus strategies in product design	2
5.5	Prototyping and iterative testing, Ethical considerations.	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the stages of the design thinking process with a suitable example illustrating each stage.
2. Describe the principles and characteristics of human-centered design. How do they influence problem-solving?
3. Analyse a real-life case where design thinking was applied to solve a user-centric problem.

Course Outcome 2 (CO2):

1. Explain the Agile Manifesto and its principles. How does Agile differ from traditional development approaches?
2. Describe the Scrum framework, including roles, artifacts, and ceremonies, with a suitable example.
3. Explain the DevOps lifecycle and discuss the role of CI/CD in modern product development.

Course Outcome 3 (CO3):

1. Apply brainstorming, mind mapping, and SCAMPER techniques to generate solutions for improving a common household product.
2. Explain the concept of prioritization in idea selection. Illustrate using a feasibility vs impact matrix.
3. Discuss the 3-Box thinking framework with an example and explain its role in strategic innovation.

Course Outcome 4 (CO4):

1. Explain customer journey mapping and its importance in enhancing user experience with a suitable example.
2. Discuss the principles of sustainable design and their application in product life cycle development.
3. Analyse the role of Design for Environment (DFE) and circular economy concepts in modern product design.

Course Outcome 5 (CO5)

1. Explain the stages of New Product Development (NPD) and the significance of the fuzzy front end (FFE).
2. Describe the concept of Minimum Viable Product (MVP) and its role in iterative product development.
3. Apply prototyping and iterative testing methods to develop a solution for a real-world problem, explaining each step.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24MEM71**

Course Name: **DESIGN THINKING AND PRODUCT DEVELOPMENT**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Define design thinking and discuss its importance in creating innovative solutions.

2 Why is human centered design important and how does it help in understanding user needs?

3 Define Agile and explain its significance in modern software development.

4 What are the main principles of DevOps?

5 What is 6-3-5 Brainwriting method?

6 Explain 3-Box Thinking framework in strategic innovation.

7 What is the service experience cycle and why is it important for creating better customer experiences?

8 What is the role of energy efficiency in sustainable design?

9 Explain the concept of minimum viable product (MVP).

10 What is the key difference between a differentiation strategy and a focus strategy?

PART B

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

Module I

11 Discuss Rams' Ten Principles of Good Design. Illustrate how these principles can be implemented in the design of consumer products. (14 marks)

OR

12 Discuss the limitations of design thinking. What challenges might organizations face when implementing this methodology and how can they overcome them. (14 marks)

Module II

13 What is Kanban methodology and how does it differ from Scrum? Discuss its focus on continuous delivery and flow management in Agile environments. (14 marks)

OR

14 Compare and contrast Agile and DevOps. How do these two methodologies complement each other in delivering software products more efficiently? (14 marks)

Module III

15 Describe SCAMPER technique with examples for each step. (14 marks)

OR

16 Compare linear and non-linear innovation. How do these two approaches influence the way companies approach strategic innovation? (14 marks)

Module IV

17 Examine the role of empathy in service design. How does understanding customer needs and emotions influence the design process and final product or service? (14 marks)

OR

18 Explain the concept of Design for Environment. How does this approach guide designer in making decisions that reduce the environmental impact of a product? (14 marks)

Module V

19 Discuss the stages of the New Product Development process. How does each stage contribute to the successful development of a product, from ideation to commercialization? (14 marks)

OR

20 Define product value and discuss the various ways it can be measured. How do companies use these measurements to refine their product development process? (14 marks)

B24MEM72	AUTOMOTIVE SYSTEMS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

The course provides a comprehensive understanding of modern automotive systems with emphasis on internal combustion engines, automotive transmission systems, vehicle chassis and braking systems, electrified vehicle drives, and comfort and convenience systems. The course introduces both conventional and emerging automotive technologies including hybrid and electric vehicle architectures. Students will gain knowledge of automotive components, operating principles, system integration, and control mechanisms used in modern vehicles.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the working principles of internal combustion engines including mixture formation, combustion processes, emissions control, cooling systems and exhaust gas systems. (Cognitive Knowledge Level: Understand)
CO 2	Compare automotive transmission systems including manual and automatic transmissions, gear mechanisms, and torque converters. (Cognitive Knowledge Level: Understand)
CO 3	Explain the design and working of automotive chassis systems including suspension, steering, wheels, tires and braking systems. (Cognitive Knowledge Level: Understand)
CO 4	Understand electrified vehicle drives including electric powertrains, hybrid vehicle configurations, regenerative braking and electric drive control. (Cognitive Knowledge Level: Understand)
CO 5	Explain automotive comfort and convenience systems including climate control, cabin systems and electrically operated vehicle accessories. (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	-	-	-	-	-	-
CO 2	3	3	1	-	1	-	-	-	-	-	-
CO 3	3	3	2	1	1	-	-	-	-	-	-
CO 4	3	3	2	1	1	-	-	-	-	-	-
CO 5	2	2	2	1	3	2	1	-	-	-	-

Assessment Pattern

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

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Engine Systems & Emission Control (8 hours)

Internal combustion engines- Ideal cycles, Actual cycles, Mixture formation, Combustion, Emissions, Charge Cycle and Supercharging, Exhaust gas recirculation. **Engine cooling**- Air cooling, Water cooling, Intercooling (Charge-air cooling), Exhaust-gas cooling, Oil and Fuel cooling

Exhaust-gas system- Purpose and design, Exhaust manifold, Catalytic converter, Particulate filter, Mufflers, Commercial vehicle exhaust gas systems, Exhaust gas measuring techniques.

MODULE 2: Transmission & Powertrain Systems (9 hours)

Transmissions Systems: Spur and internal gear type, Planetary gear boxes, Study of Manual and Automatic Transmissions, Automatic control of Gears and Gear Box- Electronically Controlled Transmission (ECT) and CVT (Continuously Variable Transmission), Commercial vehicle transmissions.

Power take-up elements and Vibration isolation- Single clutch, Dual clutch, Hydrodynamic torque converter, Vibration isolation

MODULE 3: Chassis, Steering & Braking Systems (9 hours)

Chassis systems – Basic constructions and types, Suspension- Shock absorbers, Wheels – wheel suspensions, Tires, Steering, System requirements - Power assisted steering systems, Electric Power Steering (EPS)

Brakes – Principle, Regulations, Wheel brakes – disk, Drum brakes, Brake system for passenger cars, Electrohydraulic Brake, Brake Fluids, Anti-lock Braking System (ABS), Electronic Stability Control (ESC), Braking Regeneration.

MODULE 4: Electric & Hybrid Vehicle Systems (9 hours)

Electrification of the drive- Features, Components of the electrified drive, Electrified ancillary systems, Regenerative braking system, Thermal management for electric vehicles, Charging infrastructure for electrified vehicles.

Control of electric drives - Drivetrain of an electric vehicle, Vehicle control unit for electric vehicles, Further applications of the VCU for electric vehicles.

Hybrid drives-Motivation, Functionalities of hybrid drives, Classification of hybrid drives, Classification based on drive structure, Control of a hybrid drive.

MODULE 5: Vehicle Comfort & Climate Control Systems (10 hours)

Comfort and convenience – Passenger-Compartment, Climate control- Requirements, Design and Operating principle of the A/C unit, Climate-control systems, Climate control for Hybrid and Electric vehicles, Cabin filters, Auxiliary heater systems. Comfort and convenience systems in the door and roof areas- Power-Window systems, Sunroof systems, Comfort and convenience functions in the passenger compartment- Electrical seat adjustment, Electrical steering-wheel adjustment.

Text Books

1. Robert Bosch GmbH, Automotive Handbook, Bosch Publications.
2. Heinz Heisler, Vehicle and engine technology, Butterworth-Heinemann.
3. James Larminie and John Lowry, *Electric vehicle technology explained*, Wiley publications.
4. Kirpal Singh, *Automobile Engineering* Vol.1 & Vol.2, Standard Publishers

Reference Books

1. V.A.W. Hillier, *Fundamentals of modern vehicle technology*, Butterworth-Heinemann.
2. Tom Denton, *Electric and Hybrid Vehicles*, Routledge Publishers.
3. Ljubo Vlacic, Michel Parent and Fumio Harashima, *Intelligent vehicle technologies*, Butterworth-Heinemann publications, Oxford.
4. Shimo Kim and Rakesh Shresta, *Automotive Cyber Security: Introduction Challenges and Standardization,* Springer, Singapore.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**8**
1.1	Internal combustion engines- Ideal cycles, Actual cycles, Mixture formation, Combustion, Emissions, Charge Cycle and Supercharging, Exhaust gas recirculation.	2
1.2	Engine cooling- Air cooling, Water cooling, Intercooling (Charge-air cooling), Exhaust-gas cooling, Oil and Fuel cooling	2
1.3	Exhaust-gas system- Purpose and design, Exhaust manifold, Catalytic converter, Particulate filter, Mufflers	2
1.4	Commercial vehicle exhaust gas systems, Exhaust gas measuring techniques.	2
	Module 2	**9**
2.1	Transmissions Systems: Spur and internal gear type, Planetary gear boxes	2
2.2	Study of Manual and Automatic Transmissions, Automatic control of Gears and Gear Box	2
2.3	Electronically Controlled Transmission (ECT) and CVT (Continuously Variable Transmission), Commercial vehicle transmissions.	2
2.4	Power take-up elements and Vibration isolation- Single clutch, Dual clutch, Hydrodynamic torque converter, Vibration isolation	3

	Module 3	**9**
3.1	Chassis systems – Basic constructions and types, Suspension-Shock absorbers, Wheels – wheel suspensions, Tires	2
3.2	Steering, System requirements - Power assisted steering systems, Electric Power Steering (EPS)	2
3.3	Brakes – Principle, Regulations, Wheel brakes – disk, Drum brakes, Brake system for passenger cars, Electrohydraulic Brake, Brake Fluids	2
3.4	Anti-lock Braking System (ABS), Electronic Stability Control (ESC), Braking Regeneration.	3
	Module 4	**9**
4.1	Electrification of the drive- Features, Components of the electrified drive, Electrified ancillary systems, Regenerative raking system, Thermal management for electric vehicles, Charging infrastructure for electrified vehicles.	3
4.2	Control of electric drives - Drivetrain of an electric vehicle, Vehicle control unit for electric vehicles, Further applications of the VCU for electric vehicles.	3
4.3	Hybrid drives-Motivation, Functionalities of hybrid drives, Classification of hybrid drives, Classification based on drive structure, Control of a hybrid drive.	3
	Module 5	**10**
5.1	Comfort and convenience – Passenger-Compartment, Climate control- Requirements, Design and Operating principle of the A/C unit	2
5.2	Climate-control systems, Climate control for Hybrid and Electric vehicles, Cabin filters, Auxiliary heater systems.	3
5.3	Comfort and convenience systems in the door and roof areas-Power-Window systems, Sunroof systems	2
5.4	Comfort and convenience functions in the passenger compartment-Electrical seat adjustment, Electrical steering-wheel adjustment.	3
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the differences between ideal and actual engine cycles.
2. Describe mixture formation and combustion processes in SI and CI engines.
3. What are the major engine emissions and how are they controlled?

Course Outcome 2 (CO2):

1. Explain the working principle of planetary gear transmission.
2. Differentiate between manual and automatic transmission systems.
3. Describe the working of a hydrodynamic torque converter.

Course Outcome 3 (CO3):

1. Explain the working of independent suspension systems.
2. Compare drum brakes and disc brakes.
3. Explain the principle and advantages of Anti-lock Braking System (ABS).

Course Outcome 4 (CO4):

1. Explain the components of an electric vehicle drivetrain.
2. Describe the working of regenerative braking systems.
3. Differentiate between series and parallel hybrid vehicles.

Course Outcome 5 (CO5)

1. Explain the working principle of automotive air-conditioning systems.
2. Describe different climate control systems used in modern vehicles.
3. Explain the operation of power window and electric seat adjustment systems.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24MEM72**

Course Name: **AUTOMOTIVE SYSTEMS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 List the major pollutants emitted from internal combustion engines.

2 Define supercharging and state its advantages.

3 What are the main components of a planetary gearbox?

4 List the advantages of automatic transmission systems.

5 State the functions of a suspension system in automobiles.

6 What are the advantages of electric power steering (EPS)?

7 Define regenerative braking.

8 List the components of an electric vehicle drivetrain.

9 What is the purpose of automotive climate control systems?

10 List different comfort and convenience systems used in modern cars.

PART B

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

Module 1

11 Explain mixture formation, combustion and emission control techniques in internal combustion engines. (14 Marks)

OR

12 a. Explain different engine cooling systems used in automobiles. (7 Marks)

b. Describe the construction and working of catalytic converters. (7 Marks)

Module 2

13 Explain the construction and working of manual transmission systems used in automobiles. (14 Marks)

OR

14 a. Explain the working principle of a planetary gearbox. (7 Marks)

b. Describe the working of a hydrodynamic torque converter. (7 Marks)

Module 3

15 Explain the construction and working of automotive suspension systems with suitable diagrams. (14 marks)

OR

16 a. Compare disc brakes and drum brakes. (7 Marks)

b. Explain the working of Anti-lock Braking System (ABS). (7 Marks)

Module 4

17 Explain the components and working of an electric vehicle drivetrain. (14 Marks)

OR

18 a. Explain regenerative braking in electric vehicles. (7 Marks)

b. Compare series and parallel hybrid vehicle architectures. (7 Marks)

Module 5

19 Explain the design and working of automotive air-conditioning systems and climate control systems. (14 marks)

OR

20 a. Explain power window and sunroof systems used in automobiles. (7 Marks)

b. Describe electrical seat adjustment and steering wheel adjustment systems. (7 Marks)

B24MEM73	FUNDAMENTALS OF ROBOTICS AND AUTOMATION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course provides a fundamental understanding of robotic systems and industrial automation, covering robot structure, kinematics, differential motion, dynamics, trajectory planning, and basic control. Students learn how robots are modelled, analysed, and applied in real-world industrial and service environments. The course also introduces key automation components such as sensors, actuators and communication systems, along with case studies involving AMRs, AS/RS systems, and automated material handling. Together, these topics build a solid foundation for advanced study and practical work in robotics and automation.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand the basics of robotics and its applications. (Cognitive Knowledge Level: Understand)
CO 2	Apply spatial transformation principles and kinematic modelling techniques to analyse robotic manipulators. (Cognitive Knowledge Level: Apply)
CO 3	Apply differential kinematics and Jacobian concepts to analyse robot velocities and forces. (Cognitive Knowledge Level: Apply)
CO 4	Apply fundamental principles of robot dynamics, trajectory generation, and basic control to describe robot motion behaviour. (Cognitive Knowledge Level: Apply)
CO 5	Understand the basic automation concepts and industrial case studies. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	20	10	15
Understand	40	30	35
Apply	40	60	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts: Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each, and the student should answer all the questions. Part B contains 2 questions from each module, of which the student should answer any one. Each question can have a maximum of 2 subdivisions and carry 14 marks.

SYLLABUS

MODULE 1: Introduction to Robotics (8 hours)

Definition and classifications of robots. Basic components—links, joints, actuators, sensors, end-effectors, and controllers. Robot configurations, degrees of freedom, concept of workspace, reachability, and manipulability. Overview of robot applications in industrial and service domains.

MODULE 2: Manipulator Kinematics (10 hours)

Spatial description of the position and orientation of rigid bodies-rotation and translation. Transformation of coordinates using homogeneous transformation matrices, successive transformation, and inverse transformations. Forward kinematics- full parameter and Denavit–Hartenberg (DH) representation, Basics of inverse kinematics for serial robots.

MODULE 3: Differential Kinematics and Statics (9 hours)

Forward differential kinematics and velocity propagation. Manipulator Jacobian- definition and computation, inverse differential kinematics. Static force analysis- Jacobian in force domain, introduction to singularities, and dexterity.

MODULE 4: Robot Dynamics, Trajectory Planning and Control (10 hours)

Equations of motion of robotic manipulators, forward and inverse dynamics. Dynamic formulation using Euler–Lagrange equation and Newton–Euler method, dynamic modelling of a simple robotic arm. Trajectory planning- trajectory and path, joint-space and task-space trajectory generation. Introduction to robot motion control- classification of control schemes.

MODULE 5: Industrial Automation (8 hours)

Introduction to industrial automation—types of automation. Industrial automation components- sensors, actuators, controllers, safety devices, and communication systems. Case studies in factory automation- warehouse automation using AMRs, AS/RS systems, robotic arms for material handling, and AI-enabled inventory management.

Text Books

1. Craig, J. J., *Introduction to Robotics: Mechanics and Control*, Pearson Education, 4th Edition.
2. Ghosal, A., *Robotics: Fundamental Concepts and Analysis*, Oxford University Press, 1st Edition.
3. Saha, S. K., *Introduction to Robotics*, McGraw-Hill Education, 2nd Edition.

Reference Books

1. Spong, M. W., Hutchinson, S., & Vidyasagar, M., Robot Modeling and Control, John Wiley & Sons, 1st Edition.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**8**
1.1	Definition and classifications of robots.	1
1.2	Basic components—links, joints, actuators, sensors, end-effectors, and controllers.	3
1.3	Robot configurations, degrees of freedom, concept of workspace, reachability, and manipulability.	2
1.4	Overview of robot applications in industrial and service domains.	2
	Module 2	**10**
2.1	Spatial description of the position and orientation of rigid bodies-rotation and translation.	2
2.2	Transformation of coordinates using homogeneous transformation matrices, successive transformation, and inverse transformations.	3
2.3	Forward kinematics- full parameter and Denavit–Hartenberg (DH) representation.	3
2.4	Basics of inverse kinematics for serial robots.	2
	Module 3	**9**
3.1	Forward differential kinematics and velocity propagation.	3
3.2	Manipulator Jacobian- definition and computation, inverse differential kinematics.	2
3.3	Static force analysis- Jacobian in force domain.	3
3.4	Introduction to singularities and dexterity.	1
	Module 4	**10**
4.1	Equations of motion of robotic manipulators, forward and inverse dynamics.	2
4.2	Dynamic formulation using Euler–Lagrange equation and Newton–Euler method, dynamic modelling of a simple robotic arm.	3
4.3	Trajectory planning- trajectory and path, joint-space and task-space trajectory generation.	3
4.4	Introduction to robot motion control-classification of control schemes.	2
	Module 5	**8**
5.1	Introduction to industrial automation—types of automation.	2
5.2	Industrial automation components- sensors, actuators, controllers, safety devices, and communication systems.	3
5.4	Case studies in factory automation- warehouse automation using AMRs, AS/RS systems, robotic arms for material handling, and AI-enabled inventory management.	3
	Total	**45 hours**

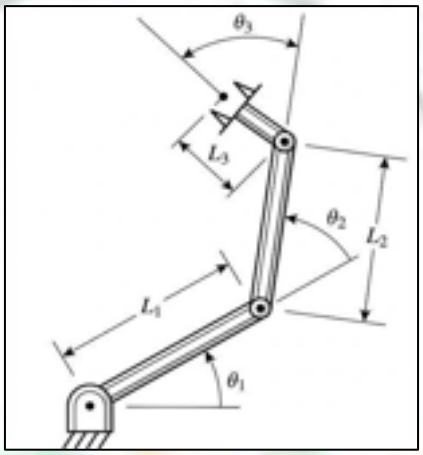
CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

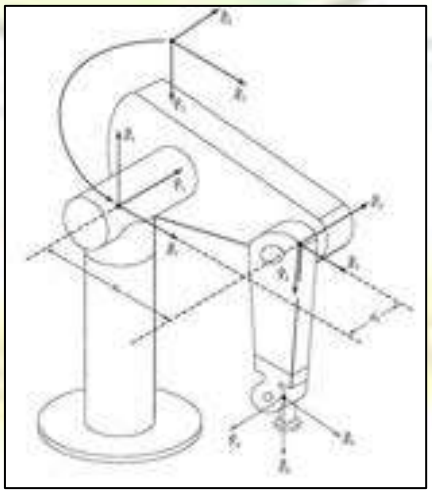
1. Explain the basic components of a robot with suitable examples for each component.
2. Differentiate between various robot configurations and discuss how they influence workspace and reachability.
3. Describe any three major applications of robots in industrial domains and explain why robots are suitable for those tasks.

Course Outcome 2 (CO2):

1. Compute the forward kinematics of the 3-link planar arm shown in the figure



2. Develop the DH parameter table for the PUMA 560 robot arm shown in the figure using the DH algorithm.



3. Compute the individual homogeneous transformation matrices for each link of a 3-link planar manipulator, and determine the end-effector pose for a given set of joint angles.

Course Outcome 3 (CO3):

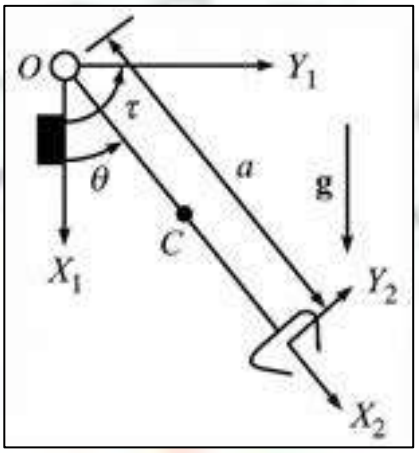
1. Calculate the Jacobian of a two-link planar arm when $\theta_1 = 45^0$ and $\theta_1 = 20^0$.
2. For a 2-link planar robot, derive the Jacobian matrix and compute the end-effector linear

velocity for a given set of joint angles and joint velocities.

3. Using the force relationship $\boldsymbol{\tau} = \mathbf{J}^T \boldsymbol{F}$, determine the joint torques required to balance a known end-effector force $[F_x, F_y]^T$ applied in the X–Y plane.

Course Outcome 4 (CO4):

1. For the one-link arm shown in the figure, assume that the link is massless, whereas the end-effector has mass m. Derive its equation of motion.



2. A single-link robot with a rotary joint is motionless at $\theta = 15°$. It is desired to move the joint in a smooth manner to $\theta_f = 75°$ in 3 seconds. Find the coefficients of a cubic that accomplishes this motion and brings the manipulator to rest at the goal.
3. Select an appropriate control scheme for a specified motion-tracking problem and justify the choice.

Course Outcome 5 (CO5)

1. Define industrial automation and explain the types of automation with suitable examples.
2. Explain any one industrial automation case study and discuss how automation improves efficiency in that application.
3. Describe how AS/RS systems improve efficiency in inventory management.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24MEM73**

Course Name: **FUNDAMENTALS OF ROBOTICS AND AUTOMATION**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the concept of degrees of freedom (DOF) and its significance in determining robot capability.
2. Describe the major components of a robot.
3. Explain how homogeneous transformation matrices are used to represent rotation and translation between coordinate frames.
4. Explain the difference between forward kinematics and inverse kinematics in robotic manipulators.
5. Define the manipulator Jacobian.
6. What is a kinematic singularity? Explain its effect on robot motion and control.
7. Explain the difference between path and trajectory in robot motion.
8. Explain the difference between the joint-space trajectory and the task-space trajectory.
9. Explain the major components of an industrial automation system.
10. Explain the role of sensors in industrial automation with one example.

PART B

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

Module 1

11. a. Describe in detail the different robot configurations. Explain how configuration affects the robot's motion and workspace. (7 marks)

    b. Explain the major classifications of robots with suitable examples. Discuss how these classifications help in selecting robots for different industrial tasks. (7 marks)

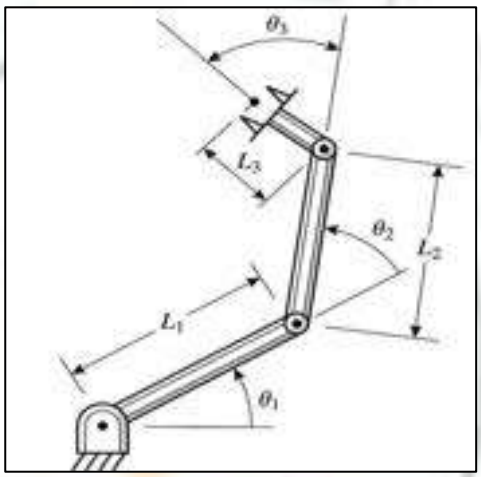
OR

12. a. Explain the concepts of workspace, reachability, and manipulability. Discuss how these parameters influence the capability of a robotic manipulator. (7 marks)

    b. Discuss the various applications of robots in industrial and service sectors. (7 marks)

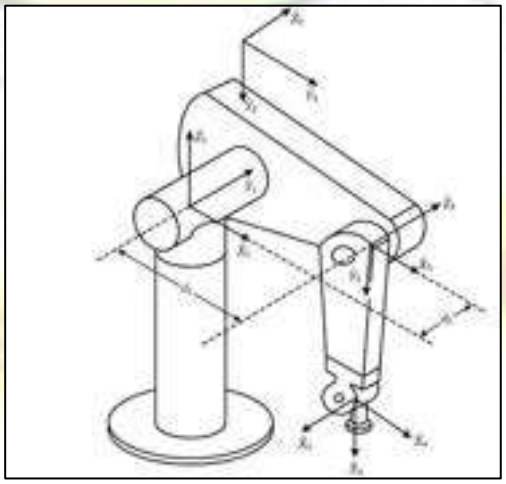
Module 2

13. Compute the forward kinematics of the 3-link planar arm shown in the figure. (14 marks)



OR

14. Develop the DH parameter table for the PUMA 560 robot arm, as shown in the figure, using the DH algorithm. (14 marks)



Module 3

15. a. Calculate the Jacobian of a two-link planar arm when $\theta_1 = 45^0$ and $\theta_1 = 20^0$. (7 marks)

    b. For a 2-link planar robot, derive the Jacobian matrix and compute the end-effector linear velocity for a given set of joint angles and joint velocities. (7 marks)

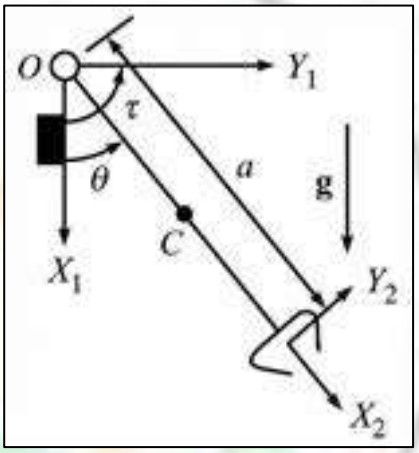
OR

16. a. Using the force relationship $\boldsymbol{\tau} = \mathbf{J}^T \boldsymbol{F}$, determine the joint torques required to balance a known end-effector force $[\boldsymbol{F_x}, \boldsymbol{F_y}]^T$ applied in the X–Y plane. (7 marks)

b. Explain inverse differential kinematics and describe how the Jacobian pseudo-inverse is used to compute joint velocities from a desired Cartesian velocity. (7 marks)

Module 4

17. For the one-link arm shown in the figure, assume that the link is massless, whereas the end-effector has mass *m*. Derive its equation of motion. (14 marks)



OR

18. A single-link robot with a rotary joint is motionless at $\theta = 15°$. It is desired to move the joint in a smooth manner to $\theta_f = 75°$ in 3 seconds. Find the coefficients of a cubic that accomplishes this motion and brings the manipulator to rest at the goal. (14 marks)

Module 5

19. Define industrial automation and explain its types, with suitable examples. (14 marks)

OR

20. Explain any one industrial automation case study and discuss how automation improves efficiency in that application. (14 marks)

MAR ATHANASIUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution
Kothamangalam, Kerala, India

B.TECH MECHANICAL ENGINEERING

SEMESTER 7

(HONOURS)

SYLLABUS

B24MEH71	TRIBOLOGY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course in Tribology is designed to provide advanced knowledge beyond the core curriculum, focusing on fundamental theories, surface characterization, lubrication mechanisms, wear analysis, and modern tribological materials and coatings. The course integrates theoretical concepts with practical applications in automotive systems, aerospace components, manufacturing processes and energy systems. Through this course, students will develop analytical skills to evaluate frictional behavior, predict wear mechanisms, select appropriate lubricants, and design tribological systems for enhanced performance and durability. Emphasis is also placed on emerging trends such as nano-tribology, green lubrication, surface engineering, and condition monitoring techniques.

Prerequisite

NIL

Course Outcomes

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

CO 1	Explain surface characteristics, contact mechanics, and adhesion phenomena in interacting surfaces. (Cognitive Knowledge Level: Understand)
CO 2	Explain frictional behavior and various wear mechanisms under different operating conditions. (Cognitive Knowledge Level: Understand)
CO 3	Apply lubrication theories to determine lubrication regimes and basic design of tribological components. (Cognitive Knowledge Level: Apply)
CO 4	Explain surface engineering techniques and advanced tribomaterials used for improving tribological performance. (Cognitive Knowledge Level: Understand)
CO 5	Apply principles of green tribology and emerging technologies to enhance energy efficiency and sustainability of tribosystems. (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	–	–	–	–	–	–	–	–	1
CO 2	3	2	–	1	–	–	–	–	–	–	1
CO 3	3	2	3	1	2	–	–	–	–	–	1
CO 4	2	1	2	–	2	–	–	–	–	–	1
CO 5	2	2	2	–	1	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	50	40
Apply		30	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 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) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

KNOWLEDGE IS POWER

SYLLABUS

MODULE 1: Surface Interactions & Contact Mechanics (9 hours)

Scope and interdisciplinary nature of tribology, Surface roughness parameters and topography characterization, Real vs. apparent area of contact, Surface energy and adhesion.

Elastic contact theory (Hertzian contact), Elastic–plastic and fully plastic contact models, Adhesion theories (Bowden & Tabor model), Subsurface stresses and failure initiation, Introduction to nanotribology.

MODULE 2: Friction & Wear Mechanisms (8 hours)

Classical laws of friction, Atomic and molecular mechanisms of friction, Stick–slip behavior and frictional instabilities, Friction under boundary and dry conditions.

Adhesive, abrasive, fatigue and tribo-chemical wear, Corrosive and oxidative wear, Wear rate equations and Archard's law, Wear maps and regime transitions, Experimental methods for friction and wear measurement.

MODULE 3: Lubrication Theory & Tribosystem Design (9 hours)

Lubrication regimes and Stribeck curve, Derivation and assumptions of Reynolds equation, Short and long bearing approximations, Film thickness estimation, Elastohydrodynamic lubrication (EHL) fundamentals.

Mixed and boundary lubrication mechanisms, Lubricant rheology and viscosity–temperature effects, Lubricant additives and tribochemistry, Design considerations for bearings, gears and seals, Failure analysis in lubricated systems.

MODULE 4: Surface Engineering & Advanced Tribomaterials (9 hours)

Physical and Chemical Vapor Deposition (PVD, CVD), Thermal spray and laser surface treatments, Diamond-like carbon (DLC) coatings.

Tribology of polymers and composites, Nanomaterials in tribology (graphene, CNTs, nanoparticles), MEMS/NEMS tribology challenges, Characterization tools: SEM, AFM, profilometry, Case studies in automotive and aerospace applications.

MODULE 5: Green Tribology & Emerging Technologies (10 hours)

Principles of green tribology, Bio-based and biodegradable lubricants, Environmentally friendly additives, Energy efficiency and friction reduction strategies, Life Cycle Assessment (LCA) of tribological systems.

Smart and self-lubricating surfaces, Additive manufacturing in tribological components, Tribology in electric vehicles and renewable energy systems, Artificial intelligence & machine learning in wear prediction, Triboinformatics and digital twin concepts, Biomedical tribology (implants and artificial joints).

Text Books

1. S. K. Basu, S. N. Sengupta, and B. B. Ahuja, *Fundamentals of Tribology*. PHI Learning Pvt. Ltd.
2. P. Sahoo, *Engineering Tribology*. PHI Learning Pvt. Ltd.

3. T. V. V. L. N. Rao, S. Binti Kasolang, G. Xie, J. K. Katiyar, and A. M. A. Rani, Green Tribology: *Emerging Technologies and Applications, Emerging Materials and Technologies.* CRC Press.

Reference Books

1. G. W. Stachowiak and A. W. Batchelor, *Engineering Tribology*, 4th ed. Butterworth-Heinemann.
2. I. Hutchings and P. Shipway, *Tribology: Friction and Wear of Engineering Materials,* 2nd ed., Butterworth-Heinemann.
3. B. Bhushan, *Introduction to Tribology*, 2nd ed. Wiley & Sons, Ltd.
4. P. J. Blau, *Friction Science and Technology: From Concepts to Applications*, 2nd ed. CRC Press / Taylor & Francis.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module1	**9**
1.1	Scope and interdisciplinary nature of tribology	1
1.2	Surface roughness parameters and topography characterization	1
1.3	Real vs. apparent area of contact, Surface energy and adhesion	1
1.4	Elastic contact theory (Hertzian contact)	1
1.5	Elastic–plastic and fully plastic contact models	2
1.6	Adhesion theories (Bowden & Tabor model)	1
1.7	Subsurface stresses and failure initiation	1
1.8	Introduction to nanotribology	1
	Module 2	**8**
2.1	Classical laws of friction, Atomic and molecular mechanisms of friction	1
2.2	Stick–slip behavior and frictional instabilities	1
2.3	Friction under boundary and dry conditions	1
2.4	Adhesive, abrasive and fatigue wear	1
2.5	Tribochemical, corrosive and oxidative wear	1
2.6	Wear rate equations and Archard's law	1
2.7	Wear maps and regime transitions	1
2.8	Experimental methods for friction and wear measurement	1
	Module 3	**9**
3.1	Lubrication regimes and Stribeck curve	1
3.2	Derivation and assumptions of Reynolds equation	1
3.3	Short and long bearing approximations	1
3.4	Film thickness estimation	1
3.5	Elastohydrodynamic lubrication (EHL) fundamentals	1
3.6	Mixed and boundary lubrication mechanisms	1

3.7	Lubricant rheology and viscosity–temperature effects	1
3.8	Lubricant additives and tribochemistry	1
3.9	Design considerations for bearings, gears and seals, Failure analysis in lubricated systems	1
	Module 4	**9**
4.1	Physical and Chemical Vapor Deposition (PVD, CVD)	1
4.2	Thermal spray and laser surface treatments	2
4.3	Diamond-like carbon (DLC) coatings	1
4.4	Tribology of polymers and composites	1
4.5	Nanomaterials in tribology (graphene, CNTs, nanoparticles)	1
4.6	MEMS/NEMS tribology challenges	1
4.7	Characterization tools: SEM, AFM, profilometry	1
4.8	Case studies in automotive and aerospace applications.	1
	Module 5	**10**
5.1	Principles of green tribology	1
5.2	Bio-based and biodegradable lubricants, Environmentally friendly additives	1
5.3	Energy efficiency and friction reduction strategies	1
5.4	Life Cycle Assessment (LCA) of tribological systems	1
5.5	Smart and self-lubricating surfaces	1
5.6	Additive manufacturing in tribological components	1
5.7	Tribology in electric vehicles and renewable energy systems	1
5.8	Artificial intelligence & machine learning in wear prediction	1
5.9	Triboinformatics and digital twin concepts	1
5.10	Biomedical tribology (implants and artificial joints)	1
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the interdisciplinary nature of tribology and its relevance to mechanical engineering applications.
2. Describe the significance of surface roughness parameters in influencing tribological performance.
3. Explain the concept of real and apparent area of contact and its importance in friction and wear behavior.

Course Outcome 2 (CO2):

1. Explain the classical laws of friction and discuss their limitations in practical applications.
2. Describe the atomic and molecular mechanisms responsible for friction in solid contacts.

3. Describe the relationship between friction behavior and wear mechanisms.

Course Outcome 3 (CO3):

1. Explain the different lubrication regimes using the Stribeck curve.
2. Describe the role of lubricant additives and tribochemistry in preventing failure in practical tribological components
3. Discuss how lubricant rheology and viscosity–temperature characteristics affect film formation and load-carrying capacity.

Course Outcome 4 (CO4):

1. Justify how suitable surface modification techniques and advanced tribomaterials can be used to enhance wear resistance in a given engineering component.
2. Explain the principles of PVD and CVD processes.
3. Explain how characterization tools such as SEM, AFM, and profilometry can be used to evaluate the effectiveness of surface treatments.

Course Outcome 5 (CO5):

1. Summarize the fundamental principles of green tribology and explain how bio-based lubricants contribute to sustainable tribological performance.
2. Discuss the role of energy efficiency, friction reduction strategies, and Life Cycle Assessment (LCA) in evaluating sustainable tribological systems.
3. Explain the significance of smart/self-lubricating surfaces and artificial intelligence in addressing tribological challenges in engineering applications.

KNOWLEDGE IS POWER

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER HONOURS DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24MEH71**

Course Name: **TRIBOLOGY**

Max. Marks: 100 Duration: 3 hours

(Any missing data may be assumed appropriately.)

PART A

Answer all questions. Each question carries 3 marks.

1. Differentiate between apparent area of contact and real area of contact.
2. Explain adhesion in tribological contacts.
3. Explain stick–slip behavior.
4. Explain Archard's wear equation.
5. List the basic assumptions made in the derivation of Reynolds equation.
6. Define mixed lubrication and explain its significance.
7. List the advantages of DLC coatings in tribological applications.
8. Mention the tribological challenges encountered in MEMS/NEMS devices.
9. What are bio-based lubricants? Mention two advantages over mineral oils.
10. How does artificial intelligence assist in wear prediction?

PART B

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

Module 1

11) Explain the importance of surface roughness parameters (Ra, Rq, Rz) and describe different surface topography characterization techniques used in tribological studies. (14 marks)

OR

12) Discuss different adhesion mechanisms and elaborate on the Bowden and Tabor adhesion theory with suitable illustrations. (14 marks)

Module 2

13) Explain the different mechanisms of sliding friction with neat sketches. (14 marks)

OR

14) Describe the different types of wear mechanisms. Explain how operating conditions affect wear behavior. (14 marks)

Module 3

15) Explain the lubrication regimes with the help of the Stribeck curve and discuss the transition from boundary to hydrodynamic lubrication. (14 marks)

OR

16) Explain the mechanisms of mixed and boundary lubrication. Discuss the role of lubricant additives and tribochemical reactions in controlling wear and friction. (14 marks)

Module 4

17) A steel component coated with DLC has a hardness of 20 GPa and operates under a normal load of 15 N with a wear coefficient of $2*10^{-6}$. Using Archard's wear equation, estimate the wear volume after a sliding distance of 1500 m. Discuss how surface coating improves wear resistance compared to uncoated steel. (14 marks)

OR

18) Discuss the tribological behavior of polymers and composites. Explain how nanomaterials such as graphene, CNTs, and nanoparticles enhance friction and wear performance. (14 marks)

Module 5

19) Explain the principles of green tribology. Discuss bio-based lubricants, biodegradable additives, and strategies for friction reduction with suitable examples from sustainable engineering systems. (14 marks)

OR

20) Explain the concepts of triboinformatics and digital twins in tribological systems. (14 marks)

KNOWLEDGE IS POWER

B24MEH72	AEROSPACE ENGINEERING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course introduces senior undergraduate students to the fundamental principles of aerodynamics, aircraft propulsion, and space technology. It emphasizes physical understanding, engineering applications, and modern aerospace systems. The course prepares students to analyze aerodynamic performance, propulsion systems, and basic orbital mechanics relevant to aircraft and space vehicles.

Prerequisites

Nil.

Course Outcomes

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

CO 1	Explain atmospheric properties and 2D aerodynamic characteristics. (Cognitive Knowledge Level: Understand)
CO 2	Analyse finite wing behaviour and compressible flow effects. (Cognitive Knowledge Level: Apply)
CO 3	Evaluate aircraft and rocket propulsion performance. (Cognitive Knowledge Level: Apply)
CO 4	Apply principles of orbital mechanics to spaceflight problems. (Cognitive Knowledge Level: Apply)
CO 5	Understand spacecraft subsystems and emerging space 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	3	2	2	1					1	
CO 2	3	2	2	1	2					1	
CO 3	3	3	2	1	2					1	
CO 4	3	3	2	2	2					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	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Atmosphere and Two-Dimensional Aerodynamics (9 hours)

Structure of Earth's Atmosphere-Standard atmosphere model, Variation of temperature, pressure and density with altitude. Dimensional analysis and aerodynamic similarity-Reynolds number and Mach number. Aerodynamic forces and coefficients. Airfoil nomenclature and classification. Pressure distribution over airfoils. Circulation theory of lift. Kutta-Joukowski condition. Boundary layer concepts. Flow separation and stall.

MODULE 2: Finite Wings and Compressible Aerodynamics (9 hours)

Finite wing aerodynamics- Wingtip vortices and downwash, Lifting line theory (conceptual). Aspect ratio and span efficiency, Induced drag. Drag polar, Skin friction and parasite drag. Compressible flow fundamentals. Mach number regimes. Critical Mach number. Shock waves (concept)- Wave drag, High-speed aircraft considerations.

MODULE 3: Propulsion and aircraft performance (10 hours)

Momentum theory of propellers- Blade element theory (concept), Propeller coefficients and performance. Turbojet and turbofan engines, RAM jet and SCRAM jet engines. Rocket propulsion fundamentals- Specific impulse, Rocket equation (no derivation). Aircraft performance analysis- Power required and power available, Climb, glide, ceiling, Range and endurance. Basic flight instruments and control surfaces. Static and dynamic stability-longitudinal, lateral and directional stability.

MODULE 4: Orbital Mechanics and Space Environment (9 hours)

Space environment and atmospheric drag- Newton's law of gravitation. Circular and elliptical orbits, Parabolic and Hyperbolic orbits. Orbital velocity and escape velocity. Kepler's laws of planetary motion. Orbital energy. Hohmann transfer orbit. Geostationary, Geosynchronous and Sun-synchronous Orbit.

MODULE 5: Spacecraft Systems and Emerging Space Technologies (8 hours)

Launch vehicle fundamentals and staging-Payload fraction and mission requirements. Satellite orbits (LEO, MEO, GEO). Spacecraft subsystems. Electric propulsion systems. Small satellite constellations. Reusable launch systems. Deep space missions. Hypersonic transport and future trends. Indian space flight program.

Reference Books

1. Anderson, J.D., *Fundamentals of Aerodynamics*, McGraw Hill.
2. Kermode, A.C., *Mechanics of Flight*, Pearson Education.
3. Bate, R.R., Mueller, D.D., and White, J.E., *Fundamentals of Astrodynamics*, Dover Publications.
4. Sutton, G.P., and Biblarz, O., *Rocket Propulsion Elements*, Wiley.
5. Wertz, J.R., and Larson, W.J., *Space Mission Analysis and Design*, Microcosm Press.

COURSE CONTENT AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**9**
1.1	Structure of Earth's Atmosphere-Standard atmosphere model, Variation of temperature, pressure and density with altitude.	2
1.2	Dimensional analysis and aerodynamic similarity-Reynolds number and Mach number. Aerodynamic forces and coefficients.	2
1.3	Airfoil Geometry and Nomenclature. Airfoil Classification: Based on Camber- Symmetric airfoils, Cambered airfoils. Based on Thickness Distribution- Thin airfoils, Thick airfoils. Based on Application- Low-speed airfoils, High-speed airfoils, Laminar flow airfoils. Based on airfoil families - NACA 4-digit series, NACA 5-digit series, Modern computational airfoils. Pressure Distribution Over Airfoils: Pressure variation over upper and lower surfaces, Relationship between velocity and pressure, Derivation of Pressure coefficient and Cl and Cd.	2
1.4	Circulation theory of lift. Kutta-Joukowski condition. Boundary layer concepts. Flow separation and stall. Airfoil Characteristics.	3
	Module 2	**9**
2.1	Wingtip vortices and downwash, lifting line theory (conceptual)-replacement of finite wing by horseshoe vortex system, lifting line theory-wing load distribution – aspect ratio, induced drag calculation of induced drag from momentum considerations.	2
2.2	Brief classification of drag: Induced drag, Parasite drag, Wave drag (brief mention). Components of parasite drag: Skin friction drag, Form drag (pressure drag), Interference drag. Skin Friction Drag- Factors affecting skin friction drag: Surface roughness, Reynolds number, Surface area, Boundary layer transition. Boundary layer formation over aircraft surfaces-Difference between Laminar boundary layer and turbulent boundary layer. Drag Polar: Graphical relationship between lift coefficient and drag coefficient	2
2.3	Introduction to Compressible Flow: Review of incompressible vs compressible flow. When compressibility effects become important. Examples in aerospace: High-speed aircraft, Jet engines, Rockets. Fundamentals of Compressible Flow: Density variations in high-speed flows. Relationship between pressure, temperature, and density. Speed of sound in a fluid.	2
2.4	Mach Number and Flow Regimes: Definition of Mach number and its physical meaning. Classification of flow regimes: Subsonic flow, Transonic flow, Supersonic flow, Hypersonic flow.	2
2.5	Critical Mach Number introduction: Definition of critical Mach number, First occurrence of local sonic flow over an airfoil. Formation of shock waves at higher speeds. Effect on lift and drag.	1

	wave drag. Methods to delay critical Mach number: Swept wings, Supercritical airfoils	
	Module 3	**10**
3.1	Introduction to propulsion: Basic principle. Difference between propeller-driven, jet engine and rocket engine. Momentum theory of propellers- Blade element theory (concept)–propeller coefficients and charts.	2
3.2	Turbojet and turbofan engines, RAM jet and SCRAM jet engines. Schematic diagram and basic working principles. Operating regimes. Rocket propulsion fundamentals- Specific impulse, Rocket equation (no derivation)	2
3.3	Aircraft performance-straight and level flight –power required and power available graphs for propeller and jet aircraft. Gliding and climbing –rate of climb, service and absolute ceilings. Gliding angle and speed of flattest glide takeoff and landing performance. length of runway required- aircraft ground run. circling flight, radius of tightest turn. Range and endurance of aeroplanes	2
3.4	Flight Instruments: airspeed indicator, calculation of true air speed. Altimeter, gyro horizon, direction indicator, vertical speed indicator, turn indicator	2
3.5	Introduction to Aircraft Control and Stability: Aircraft's three rotational axes-Longitudinal axis, Lateral axis, Vertical axis. Primary control surfaces - Elevators, ailerons and rudders. Static stability- Longitudinal Stability, Lateral Stability, Directional Stability. Dynamic stability- neutral, stable and unstable dynamic response.	2
	Module 4	**9**
4.1	Introduction to Space Environment: Vacuum conditions in space. Microgravity environment, Radiation environment (solar radiation, cosmic rays), Effects of space debris. Atmospheric drag on low Earth orbit satellites - Orbital decay, Satellite lifetime, Importance for LEO missions. Newton's Law of Gravitation: Balance between gravitational force and centrifugal motion: How satellites remain in orbit around Earth.	3
4.2	Circular and elliptical orbits, Parabolic and Hyperbolic orbits. Orbital velocity and escape velocity. Kepler's law First Law - Planets move in elliptical orbits. Second Law- Equal areas swept in equal time. Third Law- Relation between orbital period and orbital radius.	2
4.3	Orbital Energy and Transfer Orbits- Concept of orbital energy: Kinetic and potential energy in orbit. Common satellite orbits- LEO, HEO. Geostationary, Geosynchronous and Sun-synchronous orbit.	2
4.4	Hohmann Transfer Orbit. (Simple numerical examples). Gravity-assist orbital transfer. Case studies- ISRO lunar mission (Chandrayan) and Mars mission (Mangalyan).	2
	Module 5	**8**

5.1	Introduction to Launch Vehicles- Purpose of launch vehicles in space missions: Launch vehicle structure, Staging concept in rockets, Advantages of multistage launch vehicles. (Simple Numerical examples) Payload Fraction and Mission Requirements - Propellant mass, Structural mass, Payload mass. Importance of payload fraction in mission design. Communication satellites, Earth observation satellites, Space probes.	2
5.2	Spacecraft Subsystems: Power subsystem (solar panels, batteries), Communication subsystem, Attitude determination and control subsystem (ADCS), Thermal control subsystem, Propulsion subsystem, Payload subsystem. Electric Propulsion Systems - Electric propulsion principle, High efficiency compared to chemical propulsion. Applications: Satellite station keeping, Deep space missions.	2
5.3	Small Satellite Constellations - Concept of satellite constellations, Key features, Multiple satellites working together, Global coverage and continuous data. Applications: Global communication networks, Earth observation, Navigation services. Reusable Launch Systems- Concept of reusable launch vehicles, Advantages: Reduced launch cost, Increased launch frequency, Sustainable space operations.	2
5.4	Deep Space Missions: Missions beyond Earth orbit, Planetary exploration and scientific research. Hypersonic Transport-Vehicles operating at very high speeds, Future applications in rapid global transportation. Overview of major achievements of Indian space missions: Launch vehicle development, Satellite missions, Planetary exploration missions. Discussion: India's role in the global space sector.	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the structure of the standard atmosphere and describe how temperature and pressure vary with altitude.
2. Define and interpret the significance of Reynolds number and Mach number in aerodynamic similarity.
3. Explain the concept of boundary layer development and discuss how flow separation leads to stall over an airfoil.

Course Outcome 2 (CO2):

1. Explain the formation of wingtip vortices and discuss their effect on induced drag in finite wings.
2. Describe the drag polar and explain the difference between skin friction drag and

parasite drag.

3. Explain the concept of Mach number regimes and discuss the significance of the critical Mach number in high-speed flight.

Course Outcome 3 (CO3):

1. Explain the momentum theory of propellers and discuss factors influencing propeller performance.
2. Compare the working principles of turbojet and turbofan engines and discuss their typical applications.
3. Explain the concepts of specific impulse and rocket equation and discuss their importance in rocket propulsion.

Course Outcome 4 (CO4):

1. Explain Newton's law of gravitation and its role in maintaining satellite motion in orbit.
2. Differentiate between circular and elliptical orbits, and explain the concepts of orbital velocity and escape velocity.
3. Explain the concept of a Hohmann transfer orbit and discuss its importance in satellite orbit transfer.

Course Outcome 5 (CO5):

1. Explain the concept of launch vehicle staging and discuss the significance of payload fraction.
2. Describe the major spacecraft subsystems required for satellite operation.
3. Discuss emerging space technologies such as electric propulsion, small satellite constellations, and reusable launch systems.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: B24MEH72

***Course Name:* AEROSPACE ENGINEERING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks

.

1 Explain the structure of the standard atmosphere and describe the variation of temperature and pressure with altitude.

2 Define Reynolds number and Mach number and explain their significance in aerodynamic similarity.

3 Explain the formation of wingtip vortices and discuss how they contribute to induced drag in finite wings.

4 Define critical Mach number and explain its importance in high-speed aircraft design.

5 Explain the momentum theory of propellers and identify the factors affecting propeller performance.

6 Define specific impulse and explain its importance in rocket propulsion systems.

7 State Kepler's laws of planetary motion and explain their relevance to satellite orbits.

8 Define orbital velocity and escape velocity and explain their significance in spaceflight missions.

9 Describe the major spacecraft subsystems required for satellite operation.

10 Explain the concept of reusable launch systems and discuss their advantages in modern space missions.

PART B

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

Module 1

11 Explain the circulation theory of lift and interpret the Kutta–Joukowski condition for lift generation over an airfoil. (14

marks)

OR

12 Discuss pressure distribution over airfoils and examine how boundary layer development and flow separation lead to stall. (14 marks)

Module II

13 Explain the aerodynamics of finite wings and analyze the formation of wingtip vortices and downwash. Evaluate the influence of aspect ratio, span efficiency, and induced drag on aircraft performance. (14 marks)

OR

14 Explain the fundamentals of compressible flow and classify different Mach number regimes. Examine the concept of critical Mach number and shock waves, and discuss their influence on wave drag and high-speed aircraft design. (14 marks)

Module III

15 Explain the aircraft performance parameters, such as power required and power available. Analyse how these parameters influence climb performance, glide characteristics, ceiling, range, and endurance of an aircraft. (14 marks)

OR

16 Compare the aircraft propulsion systems turbojet and turbofan engines with a neat sketch. (14 marks)

Module IV

17 Analyze the concept of orbital energy and Hohmann transfer orbit, and discuss their application in satellite orbit transfer missions. (14 marks)

OR

18 Explain and compare the characteristics of Geostationary, Geosynchronous, and Sun-synchronous orbits, and evaluate their suitability for different satellite mission applications such as communication, weather monitoring, and Earth observation. (14 marks)

Module V

19 Explain the fundamentals of launch vehicles and staging and evaluate the concept of payload fraction in mission design. Describe the major spacecraft subsystems and discuss their roles in satellite operation. (14 marks)

OR

20 Discuss emerging trends in space technology, including electric propulsion systems, small satellite constellations, reusable launch systems, and deep space missions. Evaluate the significance of these technologies in shaping the future of aerospace and space exploration. (14 marks)

B24MEH73	JIGS AND FIXTURES	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		3	1	0	5	4	2024

Preamble

This course provides advanced knowledge of jigs and fixtures used in modern manufacturing systems. The subject emphasizes precision work holding, advanced locating and clamping techniques, fixture design for complex machining operations, tooling materials, metrology integration, and CAD/CAM-based design methodologies. Students will develop the ability to design, analyze, and optimize jigs and fixtures for high-precision, automated, and flexible manufacturing environments while considering economic, ergonomic, and safety aspects.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand advanced principles of locating, clamping, and datum establishment in jig and fixture design. (Cognitive Knowledge Level: Understand)
CO 2	Apply design principles for precision jigs used in drilling, reaming, tapping, boring, assembly, and inspection. (Cognitive Knowledge Level: Apply)
CO 3	Apply advanced fixture design principles for milling, turning, grinding, welding, and heat treatment operations. (Cognitive Knowledge Level: Apply)
CO 4	Understand tooling materials, advanced manufacturing techniques, metrology, and statistical quality control in tooling applications. (Cognitive Knowledge Level: Understand)
CO 5	Apply CAD/CAM, simulation, and analytical methods to develop optimized jig and fixture designs for complex engineering applications. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	1	1						
CO2	3	3	2	2	2						
CO3	3	3	3	2	2						
CO4	3	2	1	1	2						
CO5	3	3	3	3	3				2	2	

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	20	20	20
Understand	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Advanced Principles of Locating & Clamping (9 hours)

Introduction to tool design and economics. Review of locating principles. 3-2-1 locating principle. GD&T integration. Datum selection. Locator types. Errors in locating. Advanced clamping principles. Force analysis. Clamping mechanisms. Power clamping systems. Clamping safety and ergonomics.

MODULE 2: Precision Jigs Design (9 hours)

Design of drilling jigs. Box, plate, indexing, and universal jigs. Bushings and liners. Chip control and coolant delivery. Automation-compatible jigs. Jigs for reaming, tapping, and boring. Floating mechanisms. Assembly jigs. Inspection jigs. Poka-yoke principles.

MODULE 3: Advanced Fixtures Design (9 hours)

Milling fixture design. Rigidity and vibration control. Modular fixturing systems. Fixture deformation considerations. Turning fixtures. Grinding fixtures. Welding fixtures. Heat treatment fixtures. Thermal distortion management.

MODULE 4: Materials, Manufacturing & Metrology for Tooling (9 hours)

Tooling materials. Tool steels. Carbides and non-ferrous materials. Surface treatments. Advanced tooling manufacturing methods (EDM, Wire EDM, Laser Machining). Additive Manufacturing for tooling. Metrology instruments. CMM principles. Statistical Process Control. Gage R&R.

MODULE 5: Advanced Design Case Studies & CAD/CAM Integration (9 hours)

Concurrent engineering. Design documentation. Cost estimation. CAD modelling of jigs & fixtures. Assembly simulation. Kinematic analysis. FEA basics. CAM integration. Industrial case studies. Design challenges.

Text Books

1. P. H. Joshi, *Jigs and Fixtures*, Tata McGraw-Hill.
2. S. K. Jha, *Jigs, Fixtures and Die Design*, Tata McGraw-Hill.
3. K. Venkataraman, *Design of Jigs, Fixtures and Press Tools*, Tata McGraw-Hill.

Reference Books

1. Mikell P. Groover, *Fundamentals of Modern Manufacturing*, Wiley.
2. ASTM / ASME Standards (GD&T – ASME Y14.5).
3. Metrology & Quality Control textbooks.
4. CAD/CAM & FEA references.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1: Advanced Principles of Locating & Clamping	**9**
1.1	Introduction to Tool Design & Economics Review of jigs and fixtures. Classification and functional requirements. Economic considerations in tool design. Cost justification. Break-even analysis. DFMA principles.	2
1.2	Advanced Locating Principles Degrees of freedom. 3-2-1 locating principle. Deterministic locating. Over-constrained systems. Datum selection. Locator design philosophy.	3
1.3	GD&T & Locating Accuracy Integration of GD&T concepts. Datum features. Positional tolerances. Effect of tolerance stack-up on fixture design.	1
1.4	Locator Types & Error Analysis Types of locators. Adjustable locators. Diamond pins. Error sources. Accumulation of errors. Error minimization strategies.	1
1.5	Advanced Clamping Principles Clamping forces. Force analysis. Clamping mechanisms. Manual and power clamping. Clamping sequence. Safety and ergonomic considerations.	2
	Module 2: Precision Jigs Design	**9**
2.1	Drilling Jigs & Classification Principles of drilling jig design. Box jigs. Plate jigs. Indexing jigs. Universal jigs. Functional analysis.	2
2.2	Jig Bushings & Liners Types of bushings. Renewable bushings. Slip-fit and press-fit bushings. Materials and wear considerations.	2
2.3	Jigs for Reaming, Tapping & Boring Special design considerations. Floating bushings. Tool alignment. Prevention of tool failure.	2
2.4	Special Purpose Jigs Assembly jigs. Inspection jigs. Poka-yoke principles. Design for repeatability and accuracy.	2
2.5	Automation-Compatible Jigs Robotic loading considerations. Quick-change features. Ergonomic enhancements.	1
	Module 3: Advanced Fixtures Design	**9**
3.1	Milling Fixtures Design principles. Cutting force considerations. Rigidity and vibration control. Fixture layout.	3
3.2	Modular Fixturing Systems Concept of modular fixtures. Advantages. Components. Flexibility in manufacturing.	1
3.3	Turning & Grinding Fixtures Design for rotational operations. Support mechanisms. Precision	3

	considerations. Surface finish influence.	
3.4	Welding & Heat Treatment Fixtures Thermal distortion. Expansion effects. Fixture materials. Repeatability in welding operations.	2
	Module 4: Materials, Manufacturing & Metrology for Tooling	**9**
4.1	Tooling Materials & Selection Tool steels. Carbides. Non-ferrous materials. Material properties. Selection criteria.	3
4.2	Surface Treatments & Wear Control Coatings and treatments. Nitriding. Hard chrome. Friction and durability considerations.	1
4.3	Advanced Tooling Manufacturing Methods EDM. Wire EDM. Laser machining. Additive manufacturing applications.	2
4.4	Metrology & Measurement Systems Precision measurement instruments. Error sources. Accuracy in tooling components.	2
4.5	CMM & SPC Applications; CMM principles. Quality monitoring. Gage R&R. Statistical quality control	1
	Module 5: CAD/CAM & Advanced Design Applications	**9**
5.1	Integrated Tool Design Process Concurrent engineering. Design workflow. Documentation standards. Cost estimation.	2
5.2	CAD Modelling of Jigs & Fixtures Parametric modelling. Assembly modelling. Design visualization.	1
5.3	Simulation & Interference Analysis Kinematic simulation. Collision detection. Optimization strategies.	2
5.4	FEA & Structural Analysis Stress analysis. Fixture rigidity evaluation. Deformation prediction.	2
5.5	Industrial Case Studies & Design Challenge Complex fixturing problems. Automated production scenarios. Lean design considerations.	2
	Total	**45 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the 3-2-1 locating principle with a neat sketch.
2. Differentiate between deterministic locating and over-constrained locating.
3. Explain various types of locators used in fixture design.
4. Discuss the sources of locating errors and methods of minimization.
5. Explain the functional requirements of clamping devices.

Course Outcome 2 (CO2):

1. With sketches, explain box jig and plate jig.
2. Explain the design considerations for drilling jigs.
3. Discuss types of jig bushings and their applications.
4. Explain the necessity of floating bushings / holders.
5. Describe the design principles of assembly jigs.

Course Outcome 3 (CO3):

1. Explain the design requirements of milling fixtures.
2. Discuss methods of improving fixture rigidity.
3. Explain the design considerations for turning fixtures.
4. Explain the functions of welding fixtures.
5. Discuss the design challenges in heat treatment fixtures.

Course Outcome 4 (CO4):

1. Discuss the properties required for tooling materials.
2. Differentiate between hot-work and cold-work tool steels.
3. Explain the role of surface treatments in fixture life.
4. Explain the principle of a Coordinate Measuring Machine (CMM).
5. Explain the importance of SPC in tooling applications.

Course Outcome 5 (CO5)

1. Explain the advantages of CAD in fixture design.
2. Discuss the role of FEA in fixture optimization.
3. Explain kinematic simulation in jig design.
4. Describe the integration of CAM in tooling manufacture.
5. Discuss fixture design considerations for automated production lines.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24MEH73**

Course Name: **JIGS AND FIXTURES**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the purpose of locating devices in fixtures.
2. State the 3-2-1 locating principle.
3. Differentiate between jig and fixture.
4. List any three types of jig bushings.
5. Why is rigidity important in fixture design?
6. Mention two applications of welding fixtures.
7. What is meant by modular fixturing?
8. Define datum in jig design.
9. List any three properties required for tooling materials.
10. State two advantages of CAD-based fixture design.

PART B

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

Module 1

11 a. Explain various locator types with sketches. (7 marks)
b. Discuss locating errors and methods of minimization. (7 marks)

OR

12 Explain advanced clamping mechanisms and force considerations. (14 marks)

Module 2

13 a. Explain the construction and working of a box jig. (7 marks)

	b.	Discuss jig bushings and their classifications.	(7 marks)

OR

14		Explain design considerations for drilling jigs used in precision machining	(14 marks)

Module 3

15	a.	Explain design principles of milling fixtures.	(7 marks)
	b.	Discuss fixture rigidity and vibration control.	(7 marks)

OR

16	`	Explain welding fixtures and heat treatment fixtures with sketches.	(14 marks)

Module 4

17	a.	Discuss tooling materials and selection criteria.	(7 marks)
	b.	Explain surface treatments used in fixtures	(7 marks)

OR

18	a.	Explain the working principle and applications of CMM.	(7 marks)
	b.	Explain the importance of SPC in tooling applications.	(7 marks)

Module 5

19	a.	Explain the role of CAD/CAM in fixture design.	(7 marks)
	b.	Discuss FEA applications in tooling analysis.	(7 marks)

OR

20	a.	Discuss fixture design challenges in automated production systems.	(7 marks)
	b.	Describe the integration of CAM in tooling manufacture.	(7 marks)

MAR ATHANASIUS COLLEGE OF ENGINEERING

Government Aided, Autonomous Institution
Kothamangalam, Kerala, India

B.TECH MECHANICAL 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	B24ME4P5x	PROGRAMME ELECTIVE V	2-1-0-4	3	3
B	B24ME4P6x	PROGRAMME ELECTIVE VI	2-1-0-4	3	3
C	B24ME4G3x	OPEN ELECTIVE III	2-1-0-4	3	3
		AND			
H	B24ME4L13	PROJECT PHASE 2	0-0-12-3	12	6
M	B24MEM8x	MINOR PROJECT#	0-0-3-12	3	6
N	B24MEH8x	HONOURS PROJECT	0-0-6-9	6	6
			TOTAL*	30	15

#Can be done in S7 as well

* Semester total does not include the credits of honors and minor courses

** Students can take up the MOOC courses in semester 7 as well. The courses should be from the list approved by the Board of Studies.,

B24ME4P51	ADVANCED THEORY OF VIBRATION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The course aims to develop a clear understanding of the theoretical principles underlying vibrations and their significance in the design and analysis of machine parts subjected to dynamic forces. It covers various vibration analysis techniques essential for the practical solution of engineering vibration problems. Students will gain insight into the concepts of transient and nonlinear vibrations and their influence on mechanical systems. The course also emphasizes vibration measurement methods and their real-world applications, enabling learners to apply theoretical knowledge to experimental and design scenarios.

Prerequisites

Nil

Course Outcomes

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

CO 1	Apply the principles of single degree of freedom vibration systems to determine the response with and without damping. (Cognitive Knowledge Level: Apply)
CO 2	Explain the concepts of forced harmonic vibration and two degree of freedom systems. (Cognitive Knowledge Level: Understand)
CO 3	Explain the principles of multi-degree of freedom systems and the Eigenvalue problem in vibration analysis. (Cognitive Knowledge Level: Understand)
CO 4	Apply the principles of vibration analysis to solve continuous systems and transient vibrations. (Cognitive Knowledge Level: Apply)
CO 5	Apply numerical methods used in vibration analysis to solve engineering problems. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember		20	10
Understand	40	40	40
Apply	60	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Basics of Vibrations (8 hours)

Introduction to mechanical vibrations- Definitions -Types of vibrations- Degrees of freedom- Oscillatory motion — Periodic motion- Beat phenomenon. Free vibration of single degree of freedom systems with damping - Natural frequency using Energy method- Rayleigh method- Newton's method. Free vibration of single degree of freedom systems with damping- Viscous damping- Logarithmic decrement- Coulomb damping- Structural damping.

MODULE 2: Forced Vibrations & MDOF Systems (8 hours)

Forced harmonic vibration- Magnification Factor-Transmissibility- Vibration Isolation- Base Excitation-Rotating unbalance- whirling of shafts- Resonance. Vibration measuring instruments- Seismometer-Accelerometer. Two degree of freedom systems- Generalised co-ordinates- Normal mode vibration-Principal co-ordinates, Coordinate coupling.

MODULE 3: Vibration Control & Matrix Methods (7 hours)

Dynamic vibration absorbers- Vibration dampers- Numerical problems, Multi-degree of freedom systems- Matrix formulation- Influence Coefficients-Flexibility. Matrix-Stiffness matrix. Eigen Value problem: Eigen value and Eigen Vectors, Torsional vibration – 2 rotor and 3 rotor system.

MODULE 4: Continuous & Transient Vibrations (7 hours)

Vibration of continuous systems-Vibrating strings- Longitudinal vibration of rods, Transverse vibration of beams / shafts—Torsional vibration of rods. Transient vibrations- Impulse excitation.

MODULE 5: Numerical Methods in Vibrations (6 hours)

Numerical methods - Matrix Iteration – Stodola – Dunkerley’s method - Rayleigh method – Rayleigh –Ritz method.

Text Books

1. A. G. Ambekar, *Mechanical Vibrations and Noise Engineering*, PHI, New Delhi.
2. V.P. Singh, *Mechanical Vibrations* Dhanpat Rai & Co (Pvt) Ltd.

Reference Books

1. Thomson W.T, *Theory of Vibration with Applications*., PHI, New Delhi
2. Rao V and J Srinivas, *Mechanical Vibrations*, PHI, New Delhi
3. S.S Rao, *Mechanical Vibrations*, Pearson Education India

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**8**
1.1	Introduction to mechanical vibrations- Definitions -Types of vibrations- Degrees of freedom-	2
1.2	Oscillatory motion – Periodic motion- Beat phenomenon. Free vibration of single-degree-of-freedom (DOF) systems with damping	2
1.3	Natural frequency using Energy method- Rayleigh method- Newton's method	2
1.4	Free vibration of single-degree-of-freedom (DOF) systems with damping- Viscous damping- Logarithmic decrement, Coulomb damping- - Structural damping	2
	Module 2	**8**
2.1	Forced harmonic vibration- Magnification Factor -Transmissibility Vibration Isolation-Base Excitation-Rotating unbalance- whirling of shafts- Resonance	2
2.2	Vibration measuring instruments- Seismometer-Accelerometer	2
2.3	Two degrees of freedom systems- Generalised co-ordinates - Normal mode vibration	2
2.4	Principal co-ordinates-Coordinate coupling.	2
	Module 3	**7**
3.1	Dynamic vibration absorbers- Vibration dampers- Numerical problems	2
3.2	Multi degree of freedom systems- Matrix formulation- Influence Coefficients-Flexibility Matrix-Stiffness matrix	2
3.3	Eigen Value problem: Eigen value and Eigen Vectors, Torsional vibration – 2 rotor and 3 rotor system.	3
	Module 4	**7**
4.1	Vibration of continuous systems-Vibrating strings	2
4.2	Longitudinal vibration of rods—Torsional vibration of rods, Transverse vibration of beams / shafts	3
4.3	Transient vibrations- Impulse excitation	2
	Module 5	**6**
5.1	Numerical methods - Matrix Iteration – Stodola	2
5.2	Dunkerley's method - Rayleigh method	2
5.3	Rayleigh –Ritz method	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain the different types of vibrating mechanisms.
2. Describe the Energy method and the Rayleigh method.
3. Explain the different damping mechanisms.

Course Outcome 2 (CO2):

1. Describe the magnification factor and transmissibility.
2. What is normal mode vibration and coordinate coupling?
3. Explain the working of a seismometer and accelerometer.

Course Outcome 3 (CO3):

1. Describe Dynamic vibration absorbers and Vibration dampers
2. Explain the mode shape and Modal analysis.
3. What are eigenvalues and eigen vectors?

Course Outcome 4 (CO4):

1. Discuss the vibrating strings and longitudinal vibration of rods.
2. Explain the Torsional vibration of rods
3. Explain the Transient vibrations

Course Outcome 5 (CO5)

1. Explain Matrix Iteration and the Stodola method
2. Differentiate between the Rayleigh method and the Rayleigh–Ritz method
3. Explain Dunkerley's method

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

EIGHTH SEMESTER B TECH DEGREE EXAMINATION, APRIL 2028

Course Code: B24ME4P51

Course Name: **ADVANCED THEORY OF VIBRATIONS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1	Distinguish between longitudinal, transverse and torsional vibrations.
2	What are beats?
3	Explain the working of a vibrometer.
4	How does the force transmitted to the base change as the speed of the machine increases?
5	What is orthogonality of modes?
6	What are influence coefficients?
7	What is the Duhamel Integral? What is its use?
8	State the boundary conditions at the end of a string.
9	Explain the Matrix Iteration Method.
10	Write short notes on the Rayleigh Ritz Method.

PART B

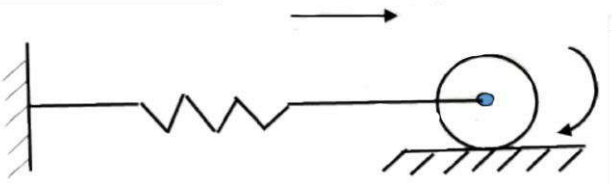
Answer any one question from each module. Each question carries 14 marks.

Module 1

11 A machine of mass 18kg is supported on springs of total stiffness 12N/mm and a dashpot of 0.2Ns/m damping. The system is initially at rest, and a velocity of 20mm/s is imparted to the machine. Determine the displacement and velocity of the machine as a function of time. (14 marks)

OR

12 A circular cylinder, as shown below, has a mass of 6 kg and radius 20 cm, which is joined to the fixture by a spring having stiffness 5000N/m. It is free to roll on the horizontal surface without slipping. Find the natural frequency of the system?



(14 marks)

Module 2

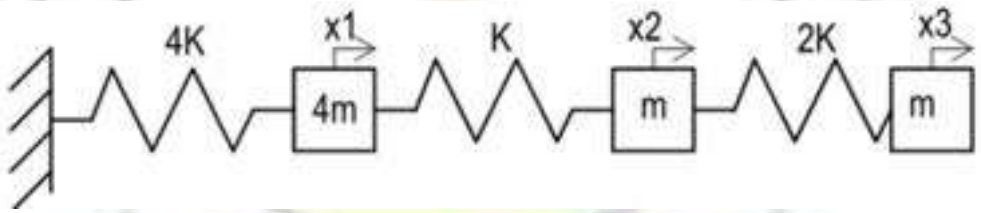
13 A machine component having a mass of 3kg vibrates in a viscous medium. If a harmonic force of 40N is applied to the system, causing a resonant amplitude of 15mm with a period of 0.25 seconds, find the damping coefficient. Find the increase in the amplitude of the forced when the damper is removed, if the frequency of the exciting force is changed to 4 Hz. (14 marks)

OR

14 Derive the general equation for damped free vibration of a single degree of freedom system. Also, derive the equation of under damped system? (14 marks)

Module 3

15 Find out the natural frequency of the system given below using the influence coefficient method.



(14 marks)

OR

16 A reciprocating machine has a weight of 250N, which runs at a constant speed of 500rpm. It was found after final installation that the forcing frequency is very close to the natural frequency of the system. Find the mass of the dynamic absorber to be added to the system, the nearest natural frequency of the system should be at least 25 percent from the impressed frequency. (14 marks)

Module 4

17 Derive an expression for the torsional vibration in the case of a shaft having torque T acting at both ends. (14 marks)

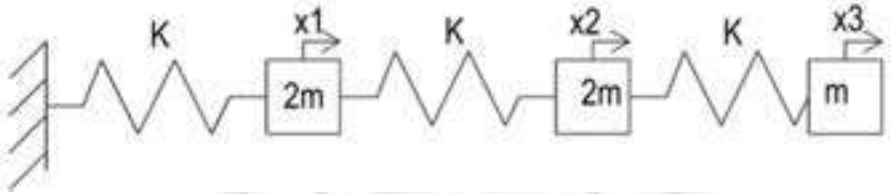
OR

18 a. Derive the impulse response function of a damped free vibration system. (7 marks)

b. A trailer being pulled at a high speed hits a h cm high curb. Considering the trailer to be single degree of freedom system, analyse the system for the response. (7marks)

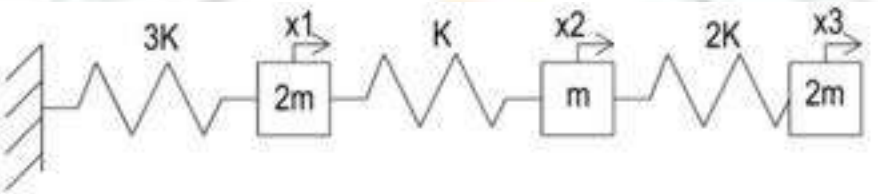
Module 5

19 Using Stodola technique determine the natural frequency of the following system? (14 marks)



OR

20 Find out the natural frequency of the system given below using matrix iteration method. (14 marks)



B24ME4P52	ACOUSTICS AND NOISE CONTROL	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces the fundamental principles of acoustics and their application to engineering problems related to sound and noise. It covers the generation, propagation, and transmission of sound waves, along with key acoustic parameters and measurement techniques. Emphasis is placed on human perception of sound, noise criteria, and standards for safe and effective acoustic design. The course also explores practical methods for noise measurement, analysis, and control in engineering systems, including the use of acoustic materials and devices. By the end of the course, students will be equipped to analyze sound behavior and design solutions for noise reduction in real-world applications.

Prerequisites

Nil

Course Outcomes

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

CO 1	Apply fundamental acoustic principles to analyze sound wave propagation and related parameters. (Cognitive Knowledge Level: Apply)
CO 2	Explain sound radiation, transmission, and reflection in different media and systems (Cognitive Knowledge Level: Understand)
CO 3	Explain human auditory response, noise criteria, and standards for acoustic design. (Cognitive Knowledge Level: Understand)
CO 4	Apply noise measurement techniques and instruments for acoustic analysis. (Cognitive Knowledge Level: Apply)
CO 5	Apply noise control methods and acoustic design principles in engineering applications. (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	–	–	–	–	–	–	–	–	–
CO 2	2	2	–	–	–	–	–	–	–	–	–
CO 3	2	–	–	–	–	2	–	–	–	–	–
CO 4	3	2	–	2	3	–	–	–	–	–	–
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	10	10	10
Understand	30	30	30
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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Fundamentals of Acoustics and Sound Wave Propagation (8 hours)

Introduction – Basic acoustic principles, sound pressure, acoustic velocity, particle velocity, acoustic wave equation, Plane acoustic wave, harmonic solution. Frequency, wavelength, acoustic impedance, sound power, sound intensity, Energy density, Decibel scale – relationship between pressure, intensity and power.

MODULE 2: Sound Radiation, Transmission and Wave Behavior (7 hours)

Spherical waves – radiation – simple source - monopole, dipole and quadrupole acoustic sources, – hemispherical source- radiating piston – pressure intensity distribution – Beam width and directivity index. Transmission through one, two and three media – Transmission through pipes – branched and unbranched, resonators – Transmission loss- reflection at plane surface, standing waves, standing wave apparatus.

MODULE 3: Human Hearing, Noise Perception and Acoustic Standards (8 hours)

Ear- Its structure and function, Hearing Thresholds, Loudness of Sound, and Sound Adaptation, Human reaction to sound – definitions of speech interference level, perceived noise level, phon and sone, hearing loss. Noise criteria and standards – noise and number index guide lines for designing quieter equipments

MODULE 4: Noise Measurement and Acoustic Instrumentation (6 hours)

Noise measurement- microphones, sound level meters, sound intensity probes, dosimeters, noise analyzer and graphic level recorder, spectrum Analysis, Measurement in anechoic and reverberation chambers.

MODULE 5: Noise Control Engineering and Industrial Acoustics (7 hours)

Principles of noise control, control at source, during transmission and at receiver- protection of receiver, Acoustic insulation – acoustic materials – acoustic filter and mufflers – plenum chamber, advanced acoustic absorbers. Principles of noise control in machinery such as pumps, rotating machines, reciprocating machines etc

Text Books

1. Lawrence E. Kinsler and Austin R. Frey, *Fundamentals of Acoustics*, John Wiley & Sons.
2. Istvan L. Ver and Leo L. Beranek, *Noise and Vibration Control Engineering*, John Wiley & Sons.
3. H. Grad, *Industrial Noise and Vibration*, McGraw-Hill.

Reference Books

1. Malcolm J. Crocker, *Handbook of Noise and Vibration Control*, John Wiley & Sons.
2. Heinrich Kuttruff, *Acoustics: An Introduction*, Taylor & Francis.
3. David A. Bies and Colin H. Hansen, *Engineering Noise Control: Theory and Practice*, Spon Press, London.
4. Michael Moser, *Engineering Acoustics*, Springer.Fourth edition, Spon press, London

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**8**
1.1	Introduction – Basic acoustic principles, sound pressure, acoustic velocity, particle velocity	2
1.2	Acoustic wave equation, Plane acoustic wave, harmonic solution	3
1.3	Frequency, wavelength, acoustic impedance, sound power, sound intensity, Energy density, Decibel scale – relationship between pressure, intensity and power	3
	Module 2	**7**
2.1	Spherical waves – radiation – simple source- monopole, dipole and quadrupole acoustic sources – hemispherical source- radiating piston – pressure intensity distribution	1
2.2	Beam width and directivity index, Transmission through one, two and three media	3
2.3	Transmission through pipes – branched and unbranched, resonators – Transmission loss- reflection at plane surface, standing waves, standing wave apparatus.	3
	Module 3	**8**
3.1	Ear- its structure and function, Hearing Thresholds, Loudness of Sound, and Sound Adaptation	2
3.2	Human reaction to sound – definitions of speech interference level, perceived noise level, phon and sone, hearing loss	3
3.3	Noise criteria and standards – noise and number index guide lines for designing quieter equipments	3
	Module 4	**6**
4.1	Noise measurement- microphones, sound level meters, sound intensity probes, dosimeters,	2
4.2	Noise analyzer and graphic level recorder, spectrum Analysis	2
4.3	Measurement in anechoic and reverberation chambers	2
	Module 5	**7**
5.1	Principles of noise control, control at source, during transmission and at receiver- protection of receiver	3
5.2	Acoustic insulation – acoustic materials – acoustic filter and muffler–plenum chamber, advanced acoustic absorbers	2
5.3	Principles of noise control in machinery such as pumps, rotating machines, reciprocating machines etc	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Derive the acoustic wave equation. Deduce the equation for a plane acoustic wave
2. Describe Acoustic impedance, Energy density and Sound intensity.
3. a) Discuss different 'levels' of sound measurement

   b) A harmonic plane wave is propagating with frequency 35 Hz in air at room temperature. The acoustic pressure at a point 1.5 m from the sound source at a time 2 s from the instant of observation is 0.2 Pa. Find the acoustic pressure at the same point at 4 s.

Course Outcome 2 (CO2):

1. Describe spherical waves, beam width and directivity index.
2. Sound wave is propagating from a fluid medium of density ρ_1 to a fluid medium of density ρ_2 at an angle of incidence θ_1. The speed of sound in the first medium is C_1, and that in the second medium is C_2. Obtain the pressure reflection and pressure transmission coefficient.
3. There was some concern that over-water flights of the supersonic transport would harm marine life. A plane sound wave from the aircraft in air (ρ = 1.1kg/m^3 , C= 347 m/s) has a sound pressure of 140 dB. The sound wave strikes the surface of the seawater (ρ = 1022kg/m^3, C=1500 m/s) normally. Determine the intensity of the transmitted wave in seawater and the magnitude of the rms acoustic pressure of the transmitted wave.

Course Outcome 3 (CO3):

1. With the help of a neat sketch, explain the hearing mechanism in human beings
2. a) Describe the speech interference level and perceived noise level

   b) Explain the threshold of hearing
3. Describe any two noise standards.

Course Outcome 4 (CO4):

1. Brief about sound level meter and the dosimeter
2. a) Explain the working of noise analyzer.

   b) What are microphones?
3. How sound is measured in a reverberation chamber and in an anechoic chamber

Course Outcome 5 (CO5)

1. Explain the absorption coefficient. What are acoustic absorbers? Brief about any one type of acoustic absorber
2. a) Suggest some measures to control the noise produced by the sound source.

   b) How can noise be controlled in reciprocating machines?
3. What are possible causes for noise in a rotating machinery? Explain some measures to control such noise

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: **B24ME4P52**

Course Name: **ACOUSTICS AND NOISE CONTROL**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 What are plane acoustic waves?

2 Explain the sound pressure level?

3 A fan alone produces a sound intensity level of 80 dB. A pump and a fan together produce an intensity level of 86.2 dB. Determine the intensity level of the sound produced by the pump.

4 What are Helmholtz resonators?

5 Describe plenum chambers.

6 Discuss phon.

7 How are standing waves generated?

8 Brief about spherical waves

9 Describe frequency weighting

10 Discuss the number noise index

PART B

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

Module 1

11 a. Derive the acoustic wave equation. Deduce the equation for a plane acoustic wave. (9 Marks)

b. A harmonic plane wave is propagating with frequency 35 Hz in air at room temperature. The acoustic pressure at a point 1.5 m from the sound source at a time 2s from the instant of observation is 0.2 Pa. Find the acoustic pressure at the same point at 4 s. (5 Marks)

OR

12 a. Elaborate about particle velocity and phase velocity (4 Marks)

b. Obtain D'Alembert's solution of the plane acoustic wave equation (7 Marks)

c. Calculate the speed of sound in air having a density of 1.225 kg/m3 and a pressure of 101 kPa. Take the adiabatic constant as 1.44. (3 Marks)

Module 2

13 a. A plane wave is incident at the boundary between air and helium at 20°C. Given that at 20°C air density is 1.2041 kg/m3, speed of sound in air is 343m/s, helium density is 0.179 kg/m3, and speed of sound in helium is 972 m/s. Find the reflection coefficient, transmission coefficient and absorption coefficient (7 marks)

b. Brief about beam width and directivity index. (5 Marks)

c. What are resonators? (2 Marks)

OR

14 a. Obtain the pressure reflection and pressure transmission coefficient for the oblique incidence of sound on a medium boundary. (10 marks)

b. Obtain the acoustic pressure developed in a pipe of length L whose one end is closed. The sound source is a vibrating piston attached to the open end of the pipe. (4 Marks)

Module 3

15 a. With a suitable figure, explain the hearing mechanism in the human ear. (8 Marks)

b. With a suitable example, describe the perceived noise level and speech interference level. (6 Marks)

OR

16 a. Humans react differently to different sounds. With suitable instances, describe human reactions to various sounds and noises. (8 Marks)

b. Brief about OSHA noise exposure criteria. (6 Marks)

Module 4

17 a. Brief about reverberation chambers and anechoic chambers. Describe in detail about how measurements are done in them. (10 marks)

b. Explain the working of a dosimeter. (4 Marks)

OR

18 a. With the help of a neat diagram, explain the working of a sound level meter. (8 marks)

b. What are microphones? Brief about any one type. (6 marks)

Module 5

19 a. Describe about
(i) Mufflers
(ii) Acoustic filers (8 Marks)

b. Brief about acoustic absorbers. (6 Marks)

OR

20 a. What are bafflers? Explain how noise reduction is attained through a baffler. (7 Marks)

b. Discuss the ways by which noise produced by rotating machines can be controlled. (7 marks)

B24ME4P53	COMPOSITE MATERIALS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course helps the students to understand the concept of various matrices and reinforcements used in composites. The course also covers about types of fibers, polymer matrix composites, metal matrix composites, ceramic matrix composites and its manufacturing and applications, micromechanics of composites

Prerequisites

Nil

Course Outcomes

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

CO1	Understand history of composites, various matrices and reinforcements used in composites (Cognitive Knowledge Level: Understand)
CO2	Understand types of fibers/ whiskers used in composites, structure, properties and applications, manufacturing process (Cognitive Knowledge Level: Understand)
CO3	Apply the knowledge of polymer matrix composites, their classification, properties, characteristics, applications, and manufacturing methods in engineering design and problem-solving. (Cognitive Knowledge Level: Apply)
CO4	Apply the knowledge of metal matrix composites, classification, properties, characteristics, applications and manufacturing methods in design and problem-solving. Alloys and their potential role as matrices in composites. To understand about intermetallics. (Cognitive Knowledge Level: Apply)
CO5	Apply the knowledge of ceramic matrix composites, classification, properties, characteristics, applications and manufacturing methods in design and problem-solving. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1								1
CO2	3	2	1								1
CO3	3	2	1								1
CO4	3	2	1								1
CO5	3	3	2		1						1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test1(%Marks)	Test2(%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 (2numbers) :25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contain 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Introduction to Composites (7 hours)

Composite: Introduction, definition, characteristics, functions, classification of composites based on structure and matrix, smart composites, advantages and limitations, history, industrial scene and applications, Interfaces: wettability and bonding interface in composites. Types of bonding at interface.

MODULE 2: Types of fibers/ whiskers used in composites (7 hours)

Fibers: Introduction, types of fibers, natural fibers, glass fiber fabrication, structure, properties and applications, boron fiber fabrication, structure, properties and applications, carbon fiber, Ex-Pan carbon fiber, Ex cellulose carbon fiber, Ex-Pitch carbon, carbon fiber structure, properties and applications, aramid fiber fabrication, structure, properties and applications, whiskers: characteristics, properties and applications.

MODULE 3: Polymer matrix composites (6 hours)

Polymer matrix composites (PMC): thermoset, thermoplastic and elastomeric polymers, properties, characteristics and applications as matrix materials, processing of polymer matrix composites: hand methods, Lay-up method, spray up method, moulding methods, pressure bagging and bag moulding methods, Autoclave-based processing with prepregs, pultrusion and filament winding process.

MODULE 4: Metal matrix composites (8 hours)

Metal matrix composites (MMC): classification of metals, intermetallics, alloys and their potential role as matrices in composites, properties, characteristics and applications of metals as matrix materials, production techniques: powder metallurgy, diffusion bonding, melt stirring, squeeze casting, liquid infiltration under pressure, in situ process.

MODULE 5: Ceramic matrix composites and Micromechanics of composites (8 hours)

Ceramic matrix composites (CMC): classification of ceramics and their potential role as matrices, properties, characteristics and applications of ceramics as matrix materials, conventional techniques: cold pressing and sintering, hot pressing, reaction bonding, liquid infiltration, pultrusion. lanxide process, in situ chemical technique, sol-gel technique, Micromechanics of composites: maximum stress and strain criterion (derivations only). Tsai-Hill and Tsai-Wu failure criterion (derivations only). Mechanics of load transfer from matrix to fiber (description).

Text Books

1. K. K. Chawla, *Composite Materials: Science and Engineering*, Springer.
2. P.K.Mallicak, *Fiber-reinforced composites*, Monal Deklar Inc., New York.
3. Reddy J. N., *Mechanics of Composite Materials*, Selected Works of Nicholas J Pagano, Springer.
4. Robert M. Jones, *Mechanics of Composite Materials*, CRC Press.

Reference Books

1. F. L. Matthews and R. D Rawlings, *Composite Materials, Engineering and Sciences*, Chapman and Hall, London.
2. George Lubin. Van Nostrand, *Hand Book of Composites*, Reinhold Co.
3. Micael Hyer, *Stress Analysis of Fiber-Reinforced Composite Materials*, Tata McGraw Hill.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No.of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Composite: Introduction, definition, characteristics, functions.	1
1.2	Classification of composites based on structure and matrix: History, industrial scene and applications.	1
1.3	Smart composites, advantages and limitations.	2
1.4	Interfaces: wettability and bonding interface in composites.	1
1.5	Types of bonding at interface.	1
	Module 2	**7**
2.1	Fibers: Introduction, types of fibers, natural fibers.	1
2.2	Fiberization, stabilisation, carbonisation, graphitization, glass fiber Fabrication, structure, properties and applications.	1
2.3	Boron fiber fabrication, structure, properties and applications.	1
2.4	Carbon fiber, Ex-Pan carbon fiber, Ex-Pitch carbon, Ex cellulose carbon Fiber.	2
2.5	Aramid fiber fabrication, structure, properties and applications.	1
2.6	Whiskers: characteristics, properties and applications.	1
	Module 3	**6**
3.1	Polymer matrix composites (PMC): thermoset, thermoplastic and Elastomeric polymers	1
3.2	Properties, characteristics and applications as matrix materials	1
3.3	Processing of polymer matrix composites: hand methods, lay-up method, spray-up method	1
3.4	Moulding methods, pressure bagging and bag moulding methods, Autoclave-based processing with prepregs	2
3.5	Pultrusion and filament winding process.	1
	Module 4	**8**
4.1	Classification of metals, intermetallics, alloys and their potential role as matrices in composites	2
4.2	Properties, characteristics and applications of metals as matrix materials	2
4.3	Production techniques: powder metallurgy, diffusion bonding, melt stirring	2
4.4	Squeeze casting, liquid infiltration under pressure, and in situ process.	2

	Module 5:	**8**
5.1	Classification of ceramics and their potential role as matrices	1
5.2	Properties, characteristics and applications of ceramics as matrix materials	1
5.3	Conventional techniques: cold pressing and sintering, hot pressing, Reaction bonding, liquid infiltration, and pultrusion.	1
5.4	Lanxide process, in situ chemical technique, sol-gel technique	1
5.5	Micromechanics of composites: maximum stress and strain criterion (derivations only)	2
5.6	Tsai-Hill and Tsai-Wu failure criterion (derivations only)	1
5.7	Mechanics of load transfer from matrix to fiber (description only)	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome1 (CO1):

1. Explain the history of the evolution of composites.
2. Explain the function of reinforcement and matrix in a composite.
3. Discuss smart composites.
4. Explain the wettability of composites.

Course Outcome 2 (CO2):

1. Compare between natural fibers and synthetic fibers.
2. With a neat sketched explain Ex-cellulose carbon fiber.
3. Explain whiskers with examples.
4. Explain Ex-Pan carbon fiber and Ex-Pitch carbon fiber fabrication.

Course Outcome 3 (CO3):

1. Discuss thermoset, thermoplastic and elastomeric polymeric materials.
2. Explain different hand lay methods.
3. Explain different moulding methods for PMC.
4. Explain the characteristics and applications of polymer matrix materials.

Course Outcome 4 (CO4):

1. How are metal matrix composites classified?
2. Explain the role of intermetallics in MMC.
3. Explain the properties, characteristics and applications of MMC.
4. Explain the different production techniques of MMC.

Course Outcome 5 (CO5):

1. How are CMCs classified and their potential role as matrix material?
2. What are the properties, characteristics and applications of CMC?
3. Explain conventional techniques for the production of CMC.
4. Explain the maximum stress and strain criterion related to micromechanics of composites.

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: **B24ME4P53**

Course Name: **COMPOSITE MATERIALS**

Max.Marks:100 Duration:3 hours

PART A

Answer all questions. Each question carries 3 marks.

1	What do you mean by smart composite?
2	What are the conditions to be satisfied for a material to be called as a composite material?
3	Compare natural fibers and synthetic fibers.
4	Discuss about aramid fiber fabrication.
5	Distinguish thermoset and thermoplastic materials.
6	List the function of components in pultrusion technique used in PMCs.
7	Name the metals and their properties used in metal matrix composites.
8	How are metal matrix composites classified?
9	What are the different failure modes of fiber composites?
10	Explain lanxide process with a neat sketch.

PART B

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

Module 1

11	a.	Which are the major constituents of a composite material? Explain the significance of each?	(7 marks)
	b.	Explain different types of bonding at interface region in composites.	(7 Marks)

OR

12	a.	What are the conditions to be satisfied for a material to be called as a composite material?	(7 Marks)
	b.	Briefly explain the various applications of composite materials.	(7 Marks)

Module 2

13 a. Explain the classification of composites based on the length of the fibers and give the significance of each? (7 Marks)

b. Explain boron fiber fabrication with a neat sketch. (7 Marks)

OR

14 a. What are carbon fibers? Give the various applications of carbon fibers. (7 Marks)

b. Classify various types of fibers used in composites materials. (7 Marks)

Module 3

15 a. Explain the significance of various polymer materials used for PMC production. (9 Marks)

b. List out the various production processes for PMCs. (5 Marks)

OR

16 a. Give a brief comparison on thermosets and thermoplastics? (6 Marks)

b. Explain filament winding process with a neat sketch. (8 Marks)

Module 4

17 a. Explain the advantages and disadvantages of Metal Matrix Composites. (5 Marks)

b. Describe the squeeze casting method for MMC production with neat figure. (9Marks)

OR

18 a. What are the advantages and disadvantages of using liquid state processes in making metal matrix composites? (6 marks)

b. Explain various solid-state production processes for Metal Matrix Composites. (8 Marks)

Module 5

19 a. What are ceramics? Explain the significance of ceramic matrix composites. (7 Marks)

b. Explain slurry infiltration process for ceramic matrix composites with a neat figure. (7 Marks)

OR

20 State and explain the Tsai-Hill and Tsai-Wu failure criteria theories. (14 Marks)

B24ME4P54	GAS DYNAMICS AND JET PROPULSION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course provides a comprehensive introduction to compressible flow phenomena and their applications in propulsion systems. It covers the fundamental principles of gas dynamics—including isentropic flow, shock waves, Fanno and Rayleigh flows—and applies these concepts to the analysis and performance of jet and space propulsion systems.

Prerequisites

Nil.

Course Outcomes

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

CO 1	Explain the fundamentals of compressible flow, including Mach number, speed of sound, atmospheric properties, and the governing conservation laws. (Cognitive Knowledge Level: Understand)
CO 2	Apply the principles of isentropic flow to determine flow properties in nozzles and diffusers under different operating conditions. (Cognitive Knowledge Level: Appy)
CO 3	Apply shock wave relations to determine the changes in flow properties across normal and oblique shocks. (Cognitive Knowledge Level: Apply)
CO 4	Apply Fanno and Rayleigh flow relations to determine the variation of flow properties in compressible flow with friction and heat transfer. (Cognitive Knowledge Level: Apply)
CO 5	Apply the working principles of jet and rocket propulsion systems and determine thrust and performance parameters. (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	1								
CO 2	3	3	1	1							
CO 3	3	3	1	1							
CO 4	3	3	1	1							
CO 5	3	2	1								

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	10	10	10
Understand	30	30	30
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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Introduction to Compressible Flow (7 hours)

Introduction to compressible flow; Differences between Incompressible and Compressible flows, Coefficient of Compressibility; Speed of sound; Mach number; Stagnation state; Critical state; Classification of flows based on Mach number- Physical significance of Mach number - Effect of Mach number on compressibility- Mach cone -. Properties of atmosphere - Conservation laws for mass, momentum and energy.

Module 2: Isentropic Variable Area Flows (7 hours)

Isentropic flow through a variable area duct; Mach number variation; Area ratio as a function of Mach number; Impulse function; Mass flow rate through nozzles and diffusers; Phenomenon of choking; subsonic and supersonic designs; Effect of back pressure; Over expanded and under-expanded nozzles; T-s and h-s diagrams showing Nozzle and Diffuser process, Supersonic wind tunnels. (Give emphasis to numerical problems using Gas Tables).

Module 3: Normal Shock Waves (7 hours)

Flow with normal shock waves; Governing equations; Prandtl relation; Impossibility of rarefaction shock; Mach number downstream of the shock; Property variations across the shock; Strength of shock wave; Entropy change and stagnation pressure drop; Rankine Hugoniot equation; Normal shock waves in Convergent-Divergent nozzles, Moving normal shock waves. Oblique shocks, Prandtl-Meyer expansion fan. (Give emphasis to numerical problems using Gas Tables).

Module 4: Fanno and Rayleigh Flow (7 hours)

Fanno flow governing equations and their closed-form solutions; Fanno curves; Variation of flow properties with duct length; Frictional choking. Rayleigh flow equations; Rayleigh line; Variation of flow properties; Maximum heat transfer, thermal choking. (Give emphasis to numerical problems using Gas Tables).

Module 5: Propulsion (8 hours)

Jet Propulsion: Theory of jet propulsion, Thrust equation, Thrust power and propulsive efficiency. Types of engines – ram jet, turbojet, turbofan and turbo-prop engines. Space propulsion: Types of rocket engines, Propellants – Ignition and combustion, Theory of rocket propulsion, ISRO Space flight program.

Text Books

1. Yahya S.M., *Fundamentals of Compressible Flow with Aircraft and Rocket propulsion,* New Age International Publishers,
2. P Balachandran, *Fundamentals of compressible fluid dynamics,* PHI.

Reference Books

1. A. H. Shapiro, *Dynamics and thermodynamics of compressible fluid flow* (Vol-1), The Ronald Press Company.
2. John D. Anderson, *Modern Compressible Flow with Historical Perspective*, McGraw-Hill.

3. James E. A. John and Theo G. Keith, *Gas Dynamics*, Pearson International.
4. Hans W. Liepmann and Anatol Roshko, *Elements of Gas Dynamics*, Dover Publications.
5. M. J. Zucrow and Joe D. Hoffman, *Gas Dynamics* (Vol. 1), John Wiley & Sons.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Introduction to compressible flow, Differences between Incompressible and Compressible flows, Coefficient of Compressibility	1
1.2	Speed of sound, Mach number	1
1.3	Stagnation state, Critical state, Classification of flows based on Mach number	1
1.4	Physical significance of Mach number, Effect of Mach number on compressibility- Mach cone	1
1.5	Properties of atmosphere, Conservation laws for mass	1
1.6	Conservation of momentum and energy	1
1.7	Numerical Examples	1
	Module 2	**7**
2.1	Isentropic flow through a variable area duct; Mach number variation	1
2.2	Area ratio as a function of Mach number; Impulse function	1
2.3	Mass flow rate through nozzles and diffusers; Phenomenon of choking	1
2.4	Subsonic and supersonic designs, Effect of back pressure, Over expanded and under-expanded nozzles, T-s and h-s diagrams showing Nozzle and Diffuser process	1
2.5	Supersonic wind tunnels	1
2.6	Numerical Examples	1
2.7	Numerical Examples	1
	Module 3	**7**
3.1	Flow with normal shock waves, Governing equations	1
3.2	Prandtl relation, Impossibility of rarefaction shock, Mach number downstream of the shock,	1
3.3	Property variations across the shock,	1
3.4	Strength of shock wave; Entropy change and stagnation pressure drop	1
3.5	Rankine Hugoniot equation; Normal shock waves in Convergent-Divergent nozzles, Moving normal shock waves	1
3.6	Oblique shocks, Prandtl-Meyer expansion fan	1
3.7	Numerical Examples	1
	Module 4	**7**

4.1	Fanno flow governing equations and their closed-form solutions, Fanno curves	1
4.2	Variation of flow properties with duct length, Frictional choking	1
4.3	Numerical Examples	1
4.4	Rayleigh flow equations, Rayleigh line	1
4.5	Variation of flow properties, Maximum heat transfer, thermal choking	1
4.6	Numerical Examples	1
4.7	Numerical Examples	1
	Module 5	**8**
5.1	Theory of jet propulsion	1
5.2	Thrust equation, Thrust power and propulsive efficiency	1
5.3	Types of engines – ram jet, turbojet, turbofan and turbo-prop engines	2
5.4	Types of rocket engines	1
5.5	Propellants – Ignition and combustion	1
5.6	Theory of rocket propulsion, ISRO Space flight program	1
5.7	Numerical Examples	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Why fluids flowing below M = 0.3 is considered incompressible?
2. Mach number play an important role in design and working of machines working on higher molecular weight fluids. Explain?
3. A cruise missile under test is moving horizontally at Mach number 2 in the atmosphere at an elevation of 305 m above earth's surface. How long does it take for an observer on the ground to hear the disturbance from the instant when it was directly overhead?

   Suppose an observer in a plane is moving in the same direction as the missile at a speed of half speed of sound at an elevation of 305 m above the missile. What is the time elapsed between the instant when the missile was directly below the observer and he hears he disturbance of missile? Neglect the change of speed of sound from 0 to610 m elevation.

Course Outcome 2 (CO2):

1. From the basic governing equations show that what should be the shape of a nozzle to attain a supersonic flow.
2. Explain chocking in isentropic flow.
3. A nozzle in a wind tunnel gives a test section Mach number of 2.0. Air enters a large reservoir 0.69 bar and 310 K. The cross-section area of the throat is 1000 cm^2. Determine the following quantities for the tunnel for 1-D isentropic flow

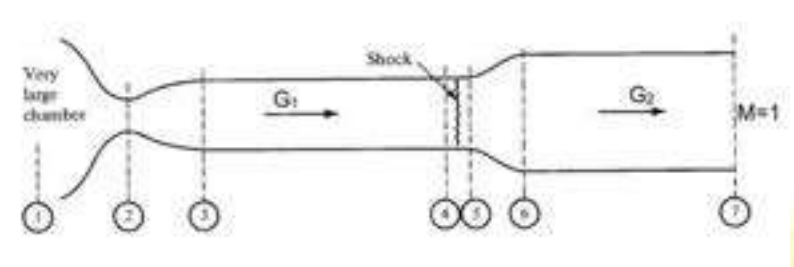
   (a) Pressure, temperature and velocity at the test section and throat., (b) Area of cross section of test section.

Course Outcome 3 (CO3):

1. What is shock strength? Explain shock of vanishing strength.
2. Fill in the following blanks with increases, decreases, or remains constant. "Across a standing normal shock, the
   (a) Static temperature ……..,
   (b) Static pressure …….
   (c) Velocity ……
   (d) Density …….
   (e) Stagnation temperature ……. and
   (f) Stagnation pressure …….. ."
3. A normal shock occurs in the divergent section of a C-D air nozzle. The throat area is $\frac{1}{3}$ *x (exit area)* and the static pressure at the exit is 0.4 times the stagnation pressure at the entry. The flow is throughout isentropic except through the shock. Determine i) the Mach number $M_x$and M_y. ii) Static pressure and iii) the area of cross-section of the nozzle at the section of the nozzle where the normal shock occurs.

Course Outcome 4 (CO4):

1. Explain friction chocking in flow through constant area ducts.
2. There is no friction in the flow passage, shown in Figure except in the constant-area ducts from 3 to 4 and from 6 to 7. Sketch the T –s diagram for the entire system? Assume the flow throughout the duct is adiabatic.



3. A convergent divergent nozzle having a throat diameter of 7.5 mm supplies air to an insulated duct of diameter 15 mm. The stagnation pressure and temperature at the entry of nozzle are 7.5 bar and 300K. Flow through the nozzle is isentropic. The mean friction factor for the duct is 0.005. Calculate maximum length of duct that can be provided without any discontinuity in the nozzle or duct. Find the condition of air at the exit, for the duct length.

Course Outcome 5 (CO5)

1. Explain the working principle of turbofan engines with the help of diagram
2. Discuss the types of rocket engines and propellants**.**
3. The exhaust velocity of a jet engine is 500 m/s and the aircraft velocity is 250 m/s**.** Determine the propulsive efficiency**.**

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

EIGHT SEMESTER B TECH DEGREE EXAMINATION, APRIL 2028

Course Code: **B24ME4P54**

Course Name: **GAS DYNAMICS AND JET PROPULSION**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1	The Explain Mach Cone, Mach Angle, Zone of Action and Zone of Silence.
2	A stationary observer on the ground will not hear the sound of a supersonic rocket, until it has passes over the observer. Why?
3	What do you understand about under expansion and over expansion in nozzles?
4	Show from the fundamentals that, an accelerating flow can be obtained (i) if the flow area is increased in a supersonic flow and (ii) if the flow area is decreased in a subsonic flow.
5	Represent normal shock on an h-s plane. Explain why shock is impossible in subsonic flow.
6	What is the Prandtl relation in normal shock waves? State its significance.
7	What is Rayleigh flow? What are the assumptions?
8	Show that Mach number is unity at the maximum entropy point on a Fanno curve.
9	With a neat sketch explain the working of a turbojet engine.
10	What are the advantages and disadvantages of solid propellant rockets?

PART B

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

Module 1

11	a.	An observer on the ground finds that an airplane flying horizontally at an altitude of 5000 m. has travelled 12 km. from the overhead position before the sound of airplane is first heard. Estimate the speed and Mach number.	(7 marks)
	b.	Air flowing in a duct has a velocity of 300m/s, pressure 1.0 bar and temperature of 290 K. Take R= 287 J/Kg K, γ=1.4, Calculate 1) Stagnation temp. and pressure, 2) Velocity of sound at stagnation temp. and 3) Stagnation pressure assuming constant density.	(7 marks)

OR

12 a. Derive the expression for the velocity of sound. (7 marks)

b. A jet of gas at 593 K (ϒ=1.3, R = 469 J/kg K) has a Mach number of 1.2. Determine the local and stagnation conditions, velocity of sound and enthalpy. Also determine the maximum attainable velocity of this jet. (7 marks)

Module 2

13 The throat and exit areas of a converging-diverging nozzle in a wind tunnel are 4 cm^2 and 10 cm^2 respectively. The reservoir conditions are 10 bar and 95^0C. Find out the Mach number, Pressure, and Temperature of the air at the test section. Also find the mass flow rate. (14 marks)

OR

14 A nozzle in a wind tunnel gives a test section Mach number of 2. Air enters the nozzle from a large reservoir at 0.69 bar and 310 K. The cross-sectional area of the throat is 1000cm^2. Determine the following quantities for the tunnel a) Pressures, temperatures and velocities at the throat and test sections, b) area of cross section of the test section, c) mass flow rate. (14 marks)

Module 3

15 a. Describe oblique shocks and Prandtl-Meyer expansion fan, highlighting the key differences between compression and expansion processes. (7 marks)

b. The stagnation pressure and temperature of air at the entry of nozzle are 5 bar and 500 K respectively. The exit Mach number is 2 where a normal shock occurs. Calculate the following quantities before and after the shock i) Static and stagnation temperature and pressure, ii) Air velocity and Mach number. What are the values of stagnation pressure loss and increase of entropy across the shock. (7 marks)

OR

16 A normal shock occurs at the divergent section of a convergent-divergent nozzle. The throat area is 1/3 times exit area and the static pressure at exit is 0.4 times the stagnation pressure at the entry. The flow is throughout isentropic except through the shock. Determine i) Mach number M_x and M_y, ii) static pressure and area of cross section of the nozzle where normal shock occurs. (14 marks)

Module 4

17 a. Air at P_0 = 10 bar, T_0 = 400 K is supplied to a 50 mm diameter pipe. The friction factor of the pipe surface is 0.002. If the Mach number changes from 3.0 at the entry to 1.0 at the exit, determine (i) the length of the pipe and (ii) the mass flow rate. (7 marks)

b. Air at 14 bar, 550 K flows through a 12 cm pipe at Mach of 0.5. Find pressure, temperature and velocity at another section of the pipe where mach is 0.6. Also find the pipe length, taking the mean friction coefficient 0.004. (7 marks)

OR

18 A circular duct of 13.4 cm diameter is fed with air by a supersonic nozzle. The stagnation pressure at the nozzle entry and the static pressures at sections 5D and 33D downstream of the nozzle are 7.00, 0.245 and 0.50 bar respectively. The nozzle

throat diameter is 6.46 cm. Determine a) Mach number at 5D and 33D. b) the mean value of skin friction between two sections. Assume isentropic flow in nozzle and the rest is Fanno flow. (14 marks)

Module 5

19 What are the main components of a gas turbine engine used for turbojet aircrafts? Show the various processes occurring in the engine on a T-S diagram. (14 marks)

OR

20 Describe the working of a Scramjet engine. What are its advantages over the ramjet engine (14 marks)

B24ME4P55	IC ENGINES COMBUSTION AND POLLUTION	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course provides a comprehensive understanding of combustion processes in internal combustion engines and their impact on performance and emissions. It covers the fundamental principles of fuel combustion, air–fuel mixtures, and flame propagation, followed by detailed analysis of combustion characteristics in spark ignition and compression ignition engines. The course also addresses the formation of pollutants, their environmental and health effects, and various emission control strategies including after-treatment technologies. Emphasis is given to modern diagnostic and measurement techniques, emission standards, and advanced methods for reducing engine emissions. By the end of the course, students will be able to analyze combustion phenomena and evaluate techniques for improving engine efficiency and minimizing environmental impact.

Prerequisites

NIL

Course Outcomes:

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

CO 1	Apply fundamental combustion principles to determine air–fuel ratio, flame characteristics, and equilibrium effects in IC engines. (Cognitive Knowledge Level: Apply)
CO 2	Explain combustion processes, knocking phenomena, and performance characteristics in spark ignition engines. (Cognitive Knowledge Level: Understand)
CO 3	Explain combustion processes, fuel injection characteristics, and performance parameters in compression ignition engines. (Cognitive Knowledge Level: Understand)
CO 4	Apply concepts of emission formation and control techniques in IC engines. (Cognitive Knowledge Level: Apply)
CO 5	Apply emission measurement techniques, instrumentation, and standards to analyze engine pollutants. (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	–	–	–	–	–	–	–	–	–
CO 2	3	2	1	–	–	–	–	–	–	–	–
CO 3	3	2	1	–	–	–	–	–	–	–	–
CO 4	3	2	2	–	2	3	2	–	–	–	–
CO 5	3	2	–	2	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	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Fundamentals of Combustion in Engines (7 hours)

Introduction: Combustion of fuel, Combustion principles, Ricardo's theory of Combustion, Combustion equations of fuels, Stoichiometric Ratio, Air Fuel Ratio, Flame velocity, Flame Propagation Laminar and Turbulent Flame Propagation in Engines (Assignment) Chemical equilibrium and dissociation. Specific heat values during combustion

MODULE 2: Combustion in Spark Ignition Engines (7 hours)

Combustion in Spark Ignition engine, Compression ratio, Stages of Combustion in SI engines, Theoretical and actual P-Θ diagram, Normal and Abnormal combustion. Flame structure and speed, Cycle by cycle variations in pressure. Knocking combustion, pre-ignition, knock and engine variables. Features and design considerations of combustion chambers. Stratified Charge combustion system and Lean Burn Combustion. After treatment devices for SI engines.

MODULE 3: Combustion in Compression Ignition Engines (7 hours)

Combustion in Compression Ignition engine, Compression ratio. Stages of Combustion in CI engines, Theoretical and actual P-Θ diagram. Spray formation at different injection pressures and droplet vaporization. Swirl Motion, Direct and indirect injection systems. Detonation and its undesirable effects. Flame structure and speed, Cycle by cycle variations in pressure with normal injection and CRDI mode. Design considerations and features of CI engine combustion chambers. After treatment devices for diesel engines.

MODULE 4: Engine Emissions and Control Techniques (8 hours)

Emissions- Major pollutants in engine exhaust, Effect of pollutant emissions on environment and human beings. Unburned Hydrocarbons, sources and their formation in SI and CI engines, CO, NOx and Soot formation in SI and CI engines. Emission control measures for HC and CO emissions from SI and CI engines. Particulate Matter in Diesel Engines, Particulate Traps, Catalytic Convertors- One way, Two way and Three-way Catalytic convertors. Complete combustion strategies for emission reduction. Electronic control of engines for emission reduction.

MODULE 5: Emission Measurement and Standards (7 hours)

Exhaust Gas Recirculation, Urea-SCR injection for NOx reduction, Detection Methods for HC, CO and NOx emissions, FID, NDIR and Chemiluminescence Analysers. Engine modifications to reduce emissions. Instrumentation to measure pollutants. 5 Gas analysers, Smoke analysers, Smoke opacity filter paper measurements. National and International Emission Standards

Text Books

1. John B. Heywood, *Internal Combustion Engine Fundamentals*, McGraw Hill Book.
2. Ganesan, V, *Internal Combustion Engines*, Tata McGraw Hill Book Co.
3. Obert E.F., *Internal Combustion Engine and Air Pollution*, International Text Book Publishers.
4. Mathur,M.L., and Sharma,R.P., *A Course in Internal Combustion Engines* DhanpatRai Publications Pvt. New Delhi.

5. Cohen,H, Rogers,G,E.C, and Saravanamuttoo, H.I.H., *Gas Turbine Theory,* Longman Group Ltd.
6. Larminie, James, and John Lowry, *Electric Vehicle Technology Explained* John Wiley and Sons.
7. Tariq Muneer and Irene Illescas García, *The automobile, In Electric Vehicles: Prospects and Challenges*, Elsevier.
8. Sheldon S. Williamson, *Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles*, Springer.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures
1	**Module 1**	7
1.1	Combustion of fuel, Combustion principles	1
1.2	Ricardo's theory of Combustion, Combustion equations of fuels	1
1.3	Stoichiometric Ratio, Air Fuel Ratio	1
1.4	Flame velocity, Flame Propagation	1
1.5	Laminar and Turbulent Flame Propagation in Engines (Assignment)	1
1.6	Chemical equilibrium and dissociation	1
1.7	Specific heat values during combustion	1
2	**Module 2**	**7**
2.1	Combustion in Spark Ignition engine, Compression ratio	1
2.2	Stages of Combustion in SI engines, Theoretical and actual P-Θ diagram	1
2.3	Normal and Abnormal combustion	1
2.4	Flame structure and speed, Cycle by cycle variations in pressure	1
2.5	Knocking combustion, pre-ignition, knock and engine variables	1
2.6	Features and design considerations of combustion chambers.	1
2.7	Stratified Charge combustion system and Lean Burn Combustion. After treatment devices for SI engines.	1
3	**Module 3**	**7**
3.1	Combustion in Compression Ignition engine, Compression ratio	1
3.2	Stages of Combustion in CI engines, Theoretical and actual P-Θ diagram	1
3.3	Spray formation at different injection pressures and droplet vaporization	1
3.4	Swirl Motion, Direct and indirect injection systems	1
3.5	Detonation and its undesirable effects	1
3.6	Flame structure and speed, Cycle by cycle variations in pressure with normal injection and CRDI mode	1
3.7	Design considerations and features of CI engine combustion chambers, After treatment devices for diesel engines	1
4	**Module 4**	**8**
4.1	Emissions- Major pollutants in engine exhaust, Effect of pollutant emissions on environment and human beings	2
4.2	Unburned Hydrocarbons, sources and their formation in SI and CI engines	1

4.3	CO, NOx and Soot formation in SI and CI engines	1
4.4	Emission control measures for HC and CO emissions from SI and CI engines	1
4.5	Particulate Matter in Diesel Engines, Particulate Traps	1
4.6	Catalytic Convertors- One way, Two way and Three-way Catalytic convertors	1
4.7	Complete combustion strategies for emission reduction, Electronic control of engines for emission reduction	1
5	**Module 5**	7
5.1	Exhaust Gas Recirculation, Urea-SCR injection for NOx reduction	1
5.2	Detection Methods for HC, CO and NOx emissions	1
5.3	FID, NDIR and Chemiluminescence Analysers	1
5.4	Engine modifications to reduce emissions	1
5.5	Instrumentation to measure pollutants	1
5.6	5 Gas analysers, Smoke analysers	1
5.7	Smoke opacity filter paper measurements, National and International Emission Standards	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome1 (CO1):

1. Define stoichiometric air–fuel ratio and calculate it for a given fuel.
2. Explain flame propagation and distinguish between laminar and turbulent flames.
3. Apply combustion equations to determine products of combustion for a hydrocarbon fuel.
4. Explain the concept of chemical equilibrium and dissociation in combustion.
5. Calculate flame velocity or related parameters using given data.

Course Outcome 2 (CO2):

1. Explain the stages of combustion in spark ignition engines with a neat sketch.
2. Distinguish between normal and abnormal combustion in SI engines.
3. Explain knocking and pre-ignition in SI engines and their effects.
4. Describe the factors affecting flame speed in SI engines.
5. Explain the design considerations of SI engine combustion chambers.

Course Outcome 3 (CO3):

1. Explain the stages of combustion in compression ignition engines.
2. Describe spray formation and droplet vaporization in CI engines.
3. Explain the role of swirl motion in combustion.

4. Distinguish between direct and indirect injection systems.
5. Explain detonation in CI engines and its effects.

Course Outcome 4 (CO4):

1. Identify major pollutants in engine exhaust and explain their formation.
2. Apply concepts to explain formation of NOx, CO, and hydrocarbons in SI/CI engines.
3. Explain the working of catalytic converters (one-way, two-way, three-way).
4. Apply emission control techniques to reduce HC and CO emissions.
5. Explain the environmental and health impacts of engine emissions.

Course Outcome 5 (CO5):

1. Explain the working principle of EGR and SCR systems for emission control.
2. Describe methods for measuring HC, CO, and NOx emissions (FID, NDIR, etc.).
3. Apply knowledge to interpret readings from a 5-gas analyzer.
4. Explain the working of smoke meters and opacity measurement techniques.
5. Describe national and international emission standards and their significance.

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: **B24ME4P55**

Course Name: **IC ENGINE COMBUSTION AND POLLUTION**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 What is combustion? Mention Richards theory of combustion.

2 Explain dissociation effect during combustion.

3 Discuss the detonation process in engines and its undesirable effects.

4 Discuss normal and abnormal combustion in engines.

5 Explain Swirl motion in CI engines.

6 Define particulate matter in the context of engines.

7 How do cycle by cycle variations in pressure affect engine performance?

8 Comment on the need for complete combustion in engines.

9 Explain the prevailing emission standards

10 Explain Smoke measurement method using filter paper.

PART B

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

Module 1

11 Discuss the term dissociation and its effects on specific heat values during combustion. (14 marks)

OR

12 Explain the laminar and turbulent flame propagation in engines. (14 Marks)

Module 2

13 With the help of P-Θ diagram explain the various stages of combustion in CI engine. (14 Marks)

OR

14 Explain Stratified charge engines & Lean burn combustion process. (14 Marks)

Module 3

15 What is the effect of injection pressure on combustion? Why is CRDI advantageous over normal injection process? (14 Marks)

OR

16 Analyse the advantages of CRDI systems over normal injection system. (14 Marks)

Module 4

17 Explain the working of a 3-way catalytic converter with suitable sketches. (14 Marks)

OR

18 Analyse the major sources of HC emissions from engines. How can you reduce its effects? (14 marks)

Module 5

19 Explain the working of a 5-gas analyzer with the help of suitable sketches. (14 Marks)

OR

20 Explain the urea SCR injection method for pollution reduction (14 Marks)

B24ME4P56	HEATING VENTILATION AND AIR CONDITIONING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course provides a fundamental understanding of HVAC principles essential for achieving thermal comfort and indoor air quality in modern buildings. It establishes a strong foundation in psychrometric analysis and cooling load estimation, progressing to the design and selection of various systems ranging from individual units to centralized chilled water plants. The curriculum also emphasizes air distribution design, control strategies (BMS), and energy-efficient practices.

Prerequisites

Nil

Course Outcomes

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

CO 1	Understand psychrometric properties, thermal comfort standards, and indoor air quality requirements for building occupants. (Cognitive Knowledge Level: Understand)
CO 2	Apply the CLTD method and cooling load principles to estimate the refrigeration capacity required for various building spaces. (Cognitive Knowledge Level: Apply)
CO 3	Understand the working principles, performance characteristics, and functional components of diverse air conditioning systems and chilled water plants. (Cognitive Knowledge Level: Understand)
CO 4	Apply duct design fundamentals and air distribution principles to analyze AHU performance and mechanical ventilation requirements. (Cognitive Knowledge Level: Apply)
CO 5	Understand HVAC control strategies, Building Management Systems (BMS), and energy efficiency measures for specialized building applications. (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					
CO 2	3	3	2	1							
CO 3	3	2	1								
CO 4	3	3	2	1		1					
CO 5	3	2	1		2	2	2				1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	20	20	20
Understand	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Fundamentals of HVAC and Psychrometrics (7 Hours)

Scope and importance of HVAC systems in buildings. Classification of HVAC systems. Psychrometric properties—dry bulb temperature, wet bulb temperature, dew point temperature, relative humidity, humidity ratio, enthalpy, and specific volume. Psychrometric chart and its applications—sensible heating and cooling, cooling and dehumidification, humidification, and adiabatic mixing of air streams. Thermal comfort—comfort conditions, effective temperature, comfort charts, and ASHRAE standards. Indoor Air Quality (IAQ)—sources of indoor pollution, ventilation requirements, fresh air standards, and air changes per hour (ACH).

MODULE 2: Cooling Load Estimation (7 Hours)

Cooling load components—heat gains through walls, windows, roofs, infiltration, and internal gains from occupants, lighting, and equipment. Sensible and latent heat loads, SHF and RSHF. Cooling load calculation using CLTD method (numerical problems). Concept of SCL and degree-day methods (brief). Ventilation and infiltration loads. Estimation of refrigeration capacity in TR, kW and BTU/hr. Basic performance parameters—COP, EER, IEER, and star rating.

MODULE 3: Air Conditioning Systems and Heat Pumps (7 Hours)

Air conditioning systems—window AC, split AC, packaged units, central AC systems. VRV/VRF systems and centralised chilled water systems. All-air and air-water systems (concept). Functional overview of refrigeration components in HVAC—compressor, condenser, evaporator, and expansion devices (discuss different types with an application perspective). Functional overview and components of chilled water systems. Chillers and Cooling towers—types, working principles, and performance (overview). Evaporative cooling (concepts only). Heat pumps—working principle, heat sources, and basic heat pump circuits.

MODULE 4: HVAC Equipment and Air Distribution (7 Hours)

Air Handling Units (AHUs)—components and functions. CAV and VAV systems—working principle and comparison. Filters (including HEPA), grilles, registers, and dampers. Fresh Air & Exhaust Systems. Duct design fundamentals—equal friction method (numerical problems) and brief introduction to static regain and velocity methods. Pressure losses in ducts and fittings (concept). Basic mechanical ventilation systems for car parks (case study).

MODULE 5: HVAC Controls and Applications (8 Hours)

HVAC control systems—thermostats, humidistats, temperature and pressure sensors, control valves, dampers, actuators, and basic control loops. Introduction to Building Management Systems (BMS) and demand-controlled ventilation. Applications of HVAC systems in residential, commercial, industrial, healthcare buildings, cold storage, and transport air conditioning (overview). Energy efficiency measures and green HVAC concepts.

Text Books

1. R.C. Arora - *Refrigeration and Air Conditioning*, PHI Learning
2. C.P. Arora - *Refrigeration and Air Conditioning*, McGraw Hill
3. Roy J. Dossat - *Principles of Refrigeration*, Pearson

Reference Books

1. W.F Stoecker, J.W. Jones, *Refrigeration and Air Conditioning*, McGraw Hill
2. ASHRAE Handbook - *Fundamentals, HVAC Systems and Equipment, HVAC Applications*

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Scope, importance, and classification of HVAC systems in buildings.	1
1.2	Psychrometric properties: dry bulb temperature, wet bulb temperature, dew point temperature, relative humidity, humidity ratio, enthalpy, and specific volume.	2
1.3	Psychrometric chart: representation and applications.	1
1.4	Psychrometric processes: sensible heating and cooling, cooling and dehumidification, humidification, and adiabatic mixing of air streams.	1
1.5	Thermal comfort: comfort conditions, effective temperature, comfort charts, and ASHRAE standards.	1
1.6	Indoor Air Quality (IAQ): sources of indoor pollution, ventilation requirements, fresh air standards, and air changes per hour (ACH).	1
	Module 2	**7**
2.1	Cooling load components: heat gains through walls, windows, roofs, infiltration, and internal gains from occupants, lighting, and equipment	2
2.2	Sensible and latent heat loads, SHF and RSHF.	1
2.3	Cooling load calculation using CLTD method: numerical problems.	1
2.4	Ventilation and infiltration loads.	1
2.5	Concept of SCL and degree-day methods: brief introduction.	1
2.6	Estimation of refrigeration capacity in TR, kW, and BTU/hr; basic performance parameters: COP, EER, IEER, and star rating.	1
	Module 3	**7**
3.1	Air conditioning systems: window AC, split AC, packaged units, and central AC systems.	2
3.2	VRV/VRF systems and centralised chilled water systems; all-air and air-water systems: concept.	1
3.3	Functional overview of refrigeration components in HVAC: compressor, condenser, evaporator, and expansion devices.	1
3.4	Functional overview and components of chilled water systems.	1
3.5	Chillers and cooling towers: types, working principles, and performance overview.	1
3.6	Evaporative cooling: concepts only; heat pumps: working principle, heat sources, and basic circuits.	1
	Module 4	**7**

4.1	Air Handling Units (AHUs): components and functions.	1
4.2	CAV and VAV systems: working principle and comparison.	1
4.3	Filters (including HEPA), grilles, registers, and dampers.	1
4.4	Fresh air and exhaust systems.	1
4.5	Duct design fundamentals: equal friction method.	1
4.6	Duct design numerical problems; brief introduction to static regain and velocity methods.	1
4.7	Pressure losses in ducts and fittings: concept; basic mechanical ventilation systems for car parks: case study.	1
	Module 5	**8**
5.1	HVAC control systems: thermostats, humidistats, temperature and pressure sensors.	2
5.2	Control valves, dampers, actuators, and basic control loops.	1
5.3	Introduction to Building Management Systems (BMS) and demand-controlled ventilation.	1
5.4	Applications of HVAC systems in residential and commercial buildings.	1
5.5	Applications in industrial buildings, healthcare buildings, and cold storage.	2
5.6	Transport air conditioning; energy efficiency measures and green HVAC concepts.	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Define dry bulb temperature, wet bulb temperature, relative humidity, and humidity ratio and explain the relationship between them on a psychrometric chart.
2. Using a psychrometric chart, show the process of cooling and dehumidification for a given entering air condition and coil apparatus dew point.
3. List common indoor air pollutants and explain how ventilation rate (ACH) and fresh air standards are used to maintain acceptable IAQ.

Course Outcome 2 (CO2):

1. Explain the procedure for determining the sensible heat gain through a west-facing wall using the CLTD method, given its area and overall heat transfer coefficient (U).
2. Distinguish between sensible heat load and latent heat load, and define SHF and RSHF with suitable expressions.
3. For a calculated room cooling load of 10 kW, determine the required refrigeration capacity in TR, and BTU/hr. Comment on star rating using COP/EER values.

Course Outcome 3 (CO3):

1. Compare window AC, split AC, packaged units, and central AC systems in terms of capacity range, installation, and typical applications.

2. Explain the basic concept of VRV systems and state two advantages of centralised chilled water systems over multiple DX units.
3. Describe the operating principle of a heat pump, indicating how it can provide both heating and cooling, and mention common heat sources used in buildings.

Course Outcome 4 (CO4):

1. Draw a simple schematic of an Air Handling Unit (AHU) and explain the function of its main components (filters, coils, fan, dampers).
2. Explain the roles of filters, grilles, registers, and dampers in an air distribution system, mentioning where each is installed.
3. Using the equal friction method, outline the steps to size the main and branch ducts for a given air flow rate and allowable pressure drop per meter.

Course Outcome 5 (CO5)

1. Explain the functions of thermostats and humidistats in maintaining indoor conditions, and give examples of where each is installed in an HVAC system.
2. What is a Building Management System (BMS)? List its key HVAC-related functions, including demand-controlled ventilation
3. List common energy efficiency measures and green HVAC strategies and briefly explain how each reduces energy consumption.

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: **B24ME4P56**

Course Name: **HEATING VENTILATION AND AIR CONDITIONING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1		Define dry bulb temperature, wet bulb temperature, and dew point temperature
2		What is meant by thermal comfort? List any four factors affecting thermal comfort?
3		Define sensible heat load, latent heat load, SHF, and RSHF
4		What is ton of refrigeration? Express 1 TR in kW and BTU/hr.
5		Distinguish between window AC and split AC systems.
6		State the functions of compressor, condenser, evaporator, and expansion device in an HVAC system.
7		What are the main components of an Air Handling Unit (AHU)?
8		Differentiate between CAV and VAV systems.
9		What is the function of a thermostat and a humidistat in HVAC control?
10		What is a Building Management System (BMS)? State any three of its HVAC applications.

PART B

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

Module 1

11	a.	Explain the scope and importance of HVAC systems in buildings. Also classify HVAC systems based on application and arrangement.	(7 marks)
	b.	Explain the psychrometric properties of moist air: dry bulb temperature, wet bulb temperature, dew point temperature, relative humidity, humidity ratio, enthalpy, and specific volume.	(7 marks)

OR

12	a.	Explain psychrometric chart and its applications in HVAC engineering.	(7 marks)
	b.	Discuss the psychrometric processes of sensible heating, sensible cooling, cooling and dehumidification, humidification, & adiabatic mixing of air streams.	(7 marks)

Module 2

13 a. Explain the different components of cooling load in an air-conditioned building. (10 marks)

b. A room has a total refrigeration load of 42 kW. Determine the refrigeration capacity required in TR and BTU/hr. (4 marks)

OR

14 a. Explain the CLTD method for cooling load estimation and discuss the steps involved in calculating sensible heat gain through a wall. (7 marks)

b. A west-facing wall of area 20 m^2 has an overall heat transfer coefficient of 2.5 W/m^2K. If the corrected CLTD is 12°C, calculate the sensible heat gain through the wall. (7 marks)

Module 3

15 a. Compare window AC, split AC, packaged units, and central AC systems with respect to construction, capacity, advantages, and applications. (7 marks)

b. Explain the concept of VRV/VRF systems and centralized chilled water systems. (7 marks)

OR

16 a. Explain the working principle and major components of a chilled water system. (7 marks)

b. Describe the types, working principles, and applications of chillers and cooling towers. Also briefly explain the working principle of a heat pump. (7 marks)

Module 4

17 a. Explain the components and functions of an Air Handling Unit (AHU) with a neat sketch. (7 marks)

b. Explain the functions of filters, grilles, registers, dampers, and fresh air/exhaust systems in HVAC air distribution. (7 marks)

OR

18 a. Explain the equal friction method for duct design. Also briefly discuss the static regain and velocity methods. (7 marks)

b. Air at a flow rate of 2.4 m^3/s is conveyed through a main duct at a recommended velocity of 6 m/s. Determine the required duct area. If a rectangular duct of aspect ratio 2:1 is used, find its dimensions. (7 marks)

Module 5

19 a. Explain the working of thermostats, humidistats, temperature sensors, pressure sensors, control valves, dampers, and actuators in HVAC systems. (7 marks)

b. With a simple block diagram, explain a basic HVAC control loop for room temperature. (7 marks)

OR

20 a. Explain the concept of Building Management Systems (BMS) and demand-controlled ventilation. (7 marks)

b. Discuss the applications of HVAC systems in residential, commercial, industrial, healthcare buildings, cold storage, and transport air conditioning. Also explain any four energy efficiency measures in green HVAC. (7 marks)

B24ME4P57	ADDITIVE MANUFACTURING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces the fundamental principles and concepts of additive manufacturing. It covers the various additive manufacturing processes and their classifications. The course also explains the scope and significance of additive manufacturing in modern engineering. Emphasis is given to the wide range of applications of additive manufacturing in different industrial sectors. This course helps students understand the importance and potential of additive manufacturing in advanced product design and development.

Prerequisites

NIL

Course Outcomes

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

CO 1	Explain the fundamental principles, classifications, and materials used in additive manufacturing for product development. (Cognitive Knowledge Level: Understand)
CO 2	Explain the slicing process in additive manufacturing. (Cognitive Knowledge Level: Understand)
CO 3	Describe liquid-based and solid-based additive manufacturing systems. (Cognitive Knowledge Level: Understand)
CO 4	Explain the various additive manufacturing technologies. (Cognitive Knowledge Level: Understand)
CO 5	Apply rapid prototyping techniques to develop engineering solutions. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	3	3	2	2	1					1	
CO 2	3	2	2	1	2					1	
CO 3	3	3	2	1	2					1	
CO 4	3	3	2	2	2					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	40	30	40
Understand	60	40	30
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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Introduction to Additive Manufacturing (8 hours)

Overview of Additive Manufacturing, Basic Principles and Product Development, ASTM standards and recommendations for Additive Manufacturing, Classification of Additive Manufacturing Processes, Materials used in Additive Manufacturing, Benefits and Challenges in Additive Manufacturing.

MODULE 2: Basic Concepts and Data Processing in Additive Manufacturing (6 hours)

Basic Concepts and Digitization Techniques, Model Reconstruction, CAD Model Preparation, Part Orientation and Support Generation, Model Slicing and Tool Path Generation, Introduction to Slicing Software.

MODULE 3: Additive Manufacturing Process Technologies and File Formats (7 hours)

Principle, process parameters, advantages, limitations, and applications of Selective Laser Melting (SLM) and Material Jetting and Binder Jetting, 3D Printing - STL File Format, STL File Issues and Tessellation, STL File Repair and Data Translation: Methods of STL file repair, generic solutions for error correction, use of translators, and introduction to newly proposed file formats for additive manufacturing.

MODULE 4: Major Additive Manufacturing Technologies (7 hours)

Principle, process parameters, advantages, limitations, and applications of Fused Deposition Modelling (FDM), Selective Laser Sintering (SLS), Stereolithography (SLA), Laminated Object Manufacturing (LOM), Directed Energy Deposition (DED) processes: Electron Beam Melting (EBM), Laser Engineering Net Shaping (LENS).

MODULE 5: Rapid Manufacturing Applications and Industrial Case Studies (8 hours)

Direct Processes: Concepts and applications of Rapid Prototyping, Rapid Tooling, and Rapid Manufacturing using additive manufacturing technologies. Indirect Processes: Concepts and procedures involved in Indirect Prototyping, Indirect Tooling, and Indirect Manufacturing. Applications of Additive Manufacturing: biomedical, manufacturing, aerospace, automotive, food, and electronics industries. Case Studies: Study of real-world applications and case studies demonstrating the implementation and benefits of additive manufacturing in different industrial fields.

Text Books

1. Gibson, I, Rosen, D W., and Stucker B., *Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing*, Springer.
2. Chua C.K., Leong K.F., and Lim C.S., *Rapid prototyping: Principles and applications*, World Scientific Publishers.
3. Chee Kai Chua, Kah Fai Leong, *3D Printing and Additive Manufacturing: Principles and Applications*, Fourth Edition of Rapid Prototyping, World Scientific Publishers.
4. Gebhardt A., *Rapid prototyping*, Hanser Gardener Publications.

Reference Books

1. Liou L.W. and Liou F.W., *Rapid Prototyping and Engineering applications: A tool box for prototype development*, CRC Press.
2. Kamrani A.K. and Nasr E.A., *Rapid Prototyping: Theory and practice*, Springer.
3. Mahamood R.M., *Laser Metal Deposition Process of Metals, Alloys, and Composite*, Springer.
4. Ehsan Toyserkani, Amir Khajepour, Stephen F. Corbin, *Laser Cladding*, CRC Press.
5. Christopher Barnatt, *3D Printing*, Explaining the Future.com.
6. Paul F Jacobs, *Stereolithography and other RP&M Technologies: from Rapid Prototyping to Rapid Tooling*, Society of Manufacturing Engineers and the Rapid Prototyping Association, New York.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**8**
1.1	Overview of Additive Manufacturing: Definition of Additive Manufacturing (AM) and its evolution, Comparison between additive manufacturing and conventional manufacturing processes, Importance and scope of additive manufacturing in modern industry, Role of additive manufacturing in rapid prototyping and rapid manufacturing, Industrial applications and future trends.	2
1.2	Basic Principles of Additive Manufacturing: Creation of 3D Model, Conversion to Standard File Format, Slicing of the Model, Layer-by-Layer Fabrication, Bonding of Layers, Post-Processing.	2
1.3	Product Development Procedure in Additive Manufacturing: Conceptual design and CAD modeling, Model verification and preparation, Part Orientation and Support Generation, Slicing and Tool Path Generation, Part Fabrication, Post-Processing, Inspection and Testing. ASTM standards and recommendations for Additive Manufacturing	2
1.4	Classification of additive manufacturing processes, Materials used in additive manufacturing - Polymer materials (PLA, ABS, Nylon, Photopolymers), Metal materials (Steel, Titanium, Aluminum, Nickel alloys), Ceramic materials, Composite materials. Material properties and selection criteria.	1
1.5	Benefits & Challenges in Additive Manufacturing.	1
	Module 2	**6**
2.1	Basic Concept — Digitization techniques: Methods of digitization-Contact scanning, Non-contact scanning (Laser scanning, Optical scanning, CT scanning), Model Reconstruction.	2
2.2	Data Processing for Additive Manufacturing Technology: CAD model preparation, Part Orientation and support generation, Model Slicing, Tool path Generation	2

2.3	Introduction to slicing software: Cura, Simplify3D, PrusaSlicer.	2
	Module 3	**7**
3.1	Selective Laser Melting (SLM): Principle, Process parameters: laser power, scan speed, layer thickness, hatch spacing, powder characteristics, Advantages and limitations, Applications.	2
3.2	Principle and working process, Advantages, limitations and Applications of Material Jetting and Binder Jetting.	2
3.3	STL Format, STL File Problems, consequence of building valid and invalid tessellated models.	2
3.4	STL file Repairs: Generic Solution, other Translators, Newly Proposed Formats.	1
	Module 4	**7**
4.1	Fused Deposition Modelling (FDM): Principle, process with Process parameters (nozzle temperature, layer thickness, deposition speed), advantages, limitations and applications	2
4.2	Stereolithography (SLA): Principle and working process, Process parameters (laser power, layer thickness, curing time) Advantages and limitations and Applications.	1
4.3	Selective Laser Sintering (SLS): Principle and working process, Process parameters (laser power, scan speed, layer thickness, powder properties), Advantages and Applications.	1
4.4	Laminated Object Manufacturing (LOM): Principle and working process, Process parameters (layer thickness, bonding temperature, cutting speed), Advantages, limitations and Applications.	1
4.5	Directed Energy Deposition (DED) processes: Electron Beam Melting (EBM): Principle and working process, Process parameters (beam power, scan speed, layer thickness), Advantages, limitations and Applications.	1
4.6	Laser Engineering Net Shaping (LENS): Principle and working process, Process parameters (laser power, powder feed rate, scan speed), Advantages, limitations and Applications.	1
	Module 5	**8**
5.1	Definition and concept of direct processes in additive manufacturing, Overview and importance of direct manufacturing methods, Advantages of direct processes	2
5.2	Concept and principle of rapid prototyping, Process workflow and technologies used, Advantages and applications in product design and development.	1
5.3	Rapid Tooling: Introduction, types, Applications in mold and tool production. Rapid Manufacturing: Concept, Applications in production of functional end-use parts.	1
5.4	Definition and concept of indirect processes, Difference between direct and indirect additive manufacturing, Industrial relevance.	1
5.5	Concept and procedure of indirect prototyping, Indirect tooling methods and applications, Indirect manufacturing process and its industrial uses.	1
5.6	Applications and Case Studies of Additive Manufacturing in biomedical field (implants, prosthetics), manufacturing industry,	2

	aerospace and automotive industries, food and electronics industries.	
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. What is additive manufacturing?
2. What is STL file?
3. What is AM process chain?

Course Outcome 2 (CO2):

1. What is Model Slicing?
2. What are the software used for Tool path generation
3. What are the software currently used for AM?
4. What are the limitations of Tool path generation?

Course Outcome 3 (CO3):

1. Explain the principle, parameters, and applications of SLM.
2. Describe the STL file format, tessellation, and common STL file issues.
3. Describe the STL file format, tessellation, and common STL file issues.

Course Outcome 4 (CO4):

1. Brief the post processing types of LENS.
2. What are process variables in FDM?
3. What are the applications of EDM?

Course Outcome 5 (CO5):

1. What are the benefits of rapid tooling?
2. What are the applications of rapid tooling?
3. What is Rapid Tooling?

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

EIGHT SEMESTER B TECH DEGREE EXAMINATION, APRIL 2028

Course Code: **B24ME4P57**
Course Name: **ADDITIVE MANUFACTURING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1	Define additive manufacturing and briefly explain how it differs from traditional subtractive manufacturing methods.
2	Discuss two major advantages of additive manufacturing compared to traditional manufacturing techniques, providing examples to support your answer.
3	Define slicing in the context of additive manufacturing and briefly explain its importance in the 3D printing process.
4	Describe three key parameters that are typically adjusted during the slicing process in additive manufacturing and explain how each parameter can influence the final printed part quality.
5	Illustrate with an example the STL file format
6	What are the limitations of SLM?
7	Brief the LOM Process.
8	What are the materials used in SLS?
9	Describe the applications of rapid tooling.
10	What are the benefits of rapid tooling?

PART B

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

Module 1

11	a.	Explain the steps in AM process chain.	(8 marks)
	b.	Write a note on the benefits and applications of AM.	(6 marks)

OR

12 a. Explain in detail the classification of additive manufacturing process on the basis of materials used. (8 marks)

b. Compare and contrast Additive, Subtractive and Formative philosophies in manufacturing. (6 marks)

Module II

13 a. Explain model slicing and slicing methodologies? (8marks)

b. Explain about data format and data interfacing in additive manufacturing. (6 marks)

OR

14 a. Explain tool path generation. What are the common tool paths used in AM process. (8 marks)

b. Explain the features of any one slicing software (6 marks)

Module III

15 a. Explain with a neat sketch the process, working principle, advantages and limitations of Selection Laser Melting (SLM). (8 marks)

b. Explain any two newly proposed file formats used other than STL (6 marks)

OR

16 a. Explain in detail the different STL file problems. (8 marks)

b. Explain the process of Material jetting with a neat sketch. (6 marks)

Module IV

17 a. With neat sketch, explain the working principle and process, advantages and limitations of Selective Laser Sintering (SLS). (8 marks)

b. Brief about strength, weakness and applications of SLA. (6 marks)

OR

18 a. With the help of neat sketch explain the process, working principle, advantages and limitations of FDM. (8 marks)

b. Write a short note on the materials used for SLS. (6 marks)

Module V

19 a. Discuss in detail about the main aspects Rapid prototyping wheel. (8 marks)

b. Explain direct tooling and indirect tooling with suitable examples. (6 marks)

OR

20 a. Explain the biomedical applications of AM. (8 marks)

b. Discuss about the benefits of Rapid prototyping. (6 marks)

B24ME4P58	POWDER METALLURGY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

The course introduces the fundamentals of powder metallurgy, including its principles, advantages, limitations, and various methods of metal powder production and selection. It covers detailed aspects of powder characteristics, testing, treatment processes, and compaction techniques along with associated defects and influencing factors. The course also emphasizes sintering mechanisms, finishing operations, and explores a wide range of PM products and their industrial applications.

Prerequisites

NIL

Course Outcomes

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

CO 1	Explain the history, applications, and significance of powder metallurgy. (Cognitive Knowledge Level: Understand)
CO 2	Measure and evaluate powder characteristics such as apparent density, tap density, flow rate, and friction index. (Cognitive Knowledge Level: Apply)
CO 3	Apply fundamental powder compaction methods to produce green compacts. (Cognitive Knowledge Level: Apply)
CO 4	Explain the mechanisms and types of sintering for the development of mechanical properties. (Cognitive Knowledge Level: Understand)
CO 5	Apply powder metallurgy concepts to applications in various engineering fields. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	3	3	2	2	1					1	
CO 2	3	2	2	1	2					1	
CO 3	3	3	2	1	2					1	
CO 4	3	3	2	2	2					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	40	10	10
Understand	60	30	30
Apply		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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Introduction to Powder Metallurgy and Metal Powder Production (7 hours)

Introduction and historical development, Basic principles of powder metallurgy, Advantages and limitations of PM process, Comparison with conventional manufacturing methods.

Methods of powder production: Chemical, Physical and Mechanical methods. Selection of metal powder production method.

MODULE 2: Metal Powder Characteristics and Metal Powder Treatment (8 hours)

Powder characteristics and testing: Chemical Composition and structure, Particle size and size distribution, Particle shape, Surface area, Apparent and tap density, Flow rate, Compressibility, Green Strength, Pyrophorocity and toxicity.

Metal Powder Treatment: Annealing, Powder mixing, Particle size reduction, Granulation, Coating on metal powders.

MODULE 3: Metal Powder Compaction (7 hours)

Introduction, Compaction principles, Die Compaction, Cold Isostatic Compaction, Dynamic Powder Compaction, Powder Roll Compaction. Factors affecting compaction, Green compact and green strength, Defects in compaction.

MODULE 4: Sintering and Finishing Operations (8 hours)

Introduction, Sintering mechanisms, Stages of Sintering, Types of Sintering, Sintering Parameters, Sintering furnaces and atmospheres, Dimensional and Microstructural Changes, Defects in Sintering, Sintering Zones.

MODULE 5: Powder Metallurgy Products and Applications (6 hours)

Bearing materials, Sintered friction materials, Tool materials and cemented carbides, Ferrites and magnetic materials, Cermets and dispersion-strengthened materials.

Text Books

1. Sinha, A. K., Introduction to Powder Metallurgy. Dhanpat Rai Publications.
2. Upadhyaya, A., & Upadhyaya, G. S., Powder Metallurgy: Science, Technology, and Materials.
3. German, R. M., Powder Metallurgy. Metal Powder Industries Federation.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Introduction and historical development, Basic principles of powder metallurgy	1
1.2	Advantages and limitations of PM process, Comparison with conventional manufacturing methods	1
1.3	Comparison with conventional manufacturing methods	1
1.4	Methods of powder production: Chemical Methods – Chemical Reduction - Chemical Decomposition of compounds.	2
1.5	Physical Methods – Electrolytic Method – Atomization and Mechanical methods. Selection of metal powder production method.	2
	Module 2	**8**
2.1	Introduction to Powder Characteristics, Particle Geometry- Particle size and size distribution - Methods of particle size measurement - Particle shape and its influence on powder behavior	1
2.2	Surface and Density Characteristics- Surface area of metal powders - Apparent density and tap density - Methods of density measurement	2
2.3	Flow and Compaction Properties - Flow rate and flowability of powders - Compressibility of metal powders - Factors affecting powder compaction.	1
2.4	Mechanical and Safety Characteristics - Green strength of powder compacts - Pyrophoricity of metal powders- Toxicity and safety considerations in powder handling	1
2.5	Metal Powder Treatment – Introduction - Need for powder treatment- Annealing of metal powders - Effects of annealing on powder properties.	1
2.6	Powder Processing Techniques - Powder mixing and blending - Particle size reduction methods. Advanced Powder Treatment - Granulation of powders -Coating on metal powders- applications and advantages of powder treatment.	2
	Module 3	**7**
3.1	Introduction to Powder Compaction, Basic steps in powder compaction process, Principles of Powder Compaction.	1
3.2	Die Compaction- Pressing operation – Compaction presses – Press selection – Factors affecting tooling design	2
3.3	Cold Isostatic Compaction - Principle of isostatic pressing – Isostatic press equipment – isostatic pressing cycle – defects due to tooling limitations.	1
3.4	Dynamic Powder Compaction - Principle of dynamic compaction - Applications and benefits	1
3.5	Powder Roll Compaction - Equipment and process steps - Advantages and industrial applications. Factors Affecting	2

	Compaction, Green Compact and Green Strength, Defects in Compaction	
	Module 4	**8**
4.1	Introduction to Sintering - Definition and objectives of sintering, Importance of sintering in powder metallurgy, Basic principles of sintering, Sintering Mechanisms,	2
.2	Stages of Sintering - Initial stage - Intermediate stage - Final stage, Types of Sintering - Solid-state sintering - Liquid phase sintering - Activated sintering- Advantages and applications of each type	2
4.3	Sintering Parameters, Sintering Furnaces – Batch type furnace – continuous sintering furnace – vacuum furnace – Electric furnace heating element	2
4.4	Sintering Atmospheres - Reducing atmospheres (Hydrogen, Carbon monoxide) - Inert atmospheres (Argon, Nitrogen) - Vacuum sintering - Importance of atmosphere control	1
4.5	Dimensional and Microstructural Changes, Defects in Sintering, Sintering Zones	1
	Module 5	**6**
5.1	Introduction to PM Products, Overview of powder metallurgy products, Advantages of PM materials in industrial applications, Classification of PM materials	1
5.2	Bearing Materials - Self-lubricating bearings - PM Bearing Materials, Properties of Bearing Materials, Applications	1
5.3	Sintered Friction Materials – Introduction - Composition and properties - Manufacturing process - Applications	1
5.4	Tool Materials and Cemented Carbides - Tool materials produced by PM, Composition and properties of cemented carbides, applications	1
5.5	Ferrites and Magnetic Materials - Types of ferrites - Properties and applications in electrical and electronic industries.	1
5.6	Cermets and Dispersion-Strengthened Materials - Definition and characteristics of cermets - Composition and applications - Dispersion-strengthened materials - Advantages and industrial uses	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Define powder metallurgy
2. Mention the basic steps involved in the powder metallurgy process
3. List four advantages of powder metallurgy

Course Outcome 2 (CO2):

1. Define particle size distribution in metal powders.

2. What is meant by apparent density of metal powder?
3. Define tap density and state its significance.

Course Outcome 3 (CO3):

1. Define powder compaction and state its purpose in powder metallurgy.
2. Define green strength of powder compacts
3. What is cold isostatic compaction

Course Outcome 4 (CO4):

1. Define sintering in powder metallurgy
2. What is solid-state sintering
3. What is the purpose of sintering atmosphere

Course Outcome 5 (CO5):

1. What are sintered friction materials**?**
2. Define cemented carbides
3. What are the advantages of PM tool materials

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

EIGHT SEMESTER B TECH DEGREE EXAMINATION, APRIL 2028

Course Code: **B24ME4P58**
Course Name: **POWDER METALLURGY**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 What are physical methods of powder production

2 What is meant by chemical methods of powder production? Give one example

3 What is flow rate of powder? How is it measured?

4 What is meant by pyrophoricity of metal powders?

5 List any three factors affecting powder compaction

6 Name any three common defects in powder compaction

7 What is the purpose of sintering atmosphere**?**

8 What is meant by neck formation during sintering?

9 What is the difference between soft ferrites and hard ferrites

10 Name the materials commonly used for PM bearings**.**

PART B

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

Module 1

11 a. Explain the steps in AM process chain. (8 marks)

b. Write a note on the benefits and applications of AM. (6 marks)

OR

12 a. Explain in detail the classification of 3D Printing process on the basis of materials used. (8 marks)

b. Compare and contrast Additive, Subtractive and Formative philosophies in manufacturing. (6 marks)

Module II

13 a. Explain the various characteristics of metal powders and their importance in powder metallurgy processes. (8marks)

b. Discuss in detail the methods used for determining particle size and particle size distribution of metal powders. (6 marks)

OR

14 a. Explain the different powder characteristics such as particle shape, surface area, apparent density, and tap density**.** (8 marks)

b. Discuss the methods of particle size reduction, granulation, and coating of metal powders used in powder metallurgy. (6 marks)

Module III

15 a. Explain with a neat sketch the process, working principle, advantages and limitations of Selection Laser Melting (SLM). (8 marks)

b. Explain any two newly proposed file formats used other than STL (6 marks)

OR

16 a. Explain in detail the different STL file problems. (8 marks)

b. Explain the process of Material jetting with a neat sketch. (6 marks)

Module IV

17 a. Explain the principles and objectives of sintering in powder metallurgy. (8 marks)

b. Describe the various mechanisms of sintering, including different diffusion processes. (6 marks)

OR

18 a. Describe the types of sintering furnaces and their working principles. (8 marks)

b. Discuss the common defects in sintered components, their causes, and prevention methods. (6 marks)

Module V

19 a. Explain the manufacture, properties, and applications of self-lubricating bearings produced by powder metallurgy. (8 marks)

b. Discuss the composition, properties, and applications of sintered friction materials used in clutch and brake systems. (6 marks)

OR

20 a. Discuss the types, properties, and applications of ferrites and magnetic materials produced by powder metallurgy. (8 marks)

b. Explain the structure, properties, and applications of cermets in engineering industries. (6 marks)

B24ME4P59	METAL FORMING AND INJECTION MOULDING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course provides integrated knowledge of sheet metal press working and plastic moulding technologies widely used in modern manufacturing industries. The course covers press tool design, bending and forming dies, and essential polymer moulding processes including injection moulding, compression moulding, transfer moulding, and blow moulding. Emphasis is placed on tooling principles, material behavior, manufacturing considerations, defect control, and industrial applications through real-life case studies.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the fundamentals of sheet metal press working operations and die design principles. (Cognitive Knowledge Level: Understand)
CO 2	Apply press tool design principles including cutting force analysis, strip layout, and progressive die concepts. (Cognitive Knowledge Level: Apply)
CO 3	Understand injection moulding machines, mould design principles, and industrial applications. (Cognitive Knowledge Level: Understand)
CO 4	Explain compression moulding and transfer moulding processes with tooling considerations. (Cognitive Knowledge Level: Understand)
CO 5	Understand blow moulding processes, product design aspects, defects, and industrial applications. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	-	-	-	-	-	-	-	1
CO2	3	3	3	1	2	-	-	-	-	1	1
CO3	3	2	2	-	1	-	-	-	-	-	1
CO4	3	2	2	-	1	-	-	-	-	-	1
CO5	3	2	2	-	1	-	-	-	-	-	1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	40	40
Understand	40	60	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1: Fundamentals of Sheet Metal Press Working (7 hours)

Sheet metal characteristics and applications. Press working operations. Blanking, piercing, bending, forming. Types of dies. Cutting mechanisms. Press working terminology. Die materials. Heat treatment considerations. Manufacturing considerations.

Industrial Case Study: Progressive Tool for Door Hinges
Study of strip layout, operations sequencing, material utilization, and production considerations.

MODULE 2: Press Tool Design & Die Calculations (7 hours)

Design of cutting dies. Strip layout. Percentage utilization. Cutting force analysis. Press tonnage calculation. Die clearance. Bending force basics. Developed length. Spring back considerations. Standards and specifications.

Industrial Case Study: Compound vs Progressive Die – Sheet Metal Brackets / Hinges
Comparison of productivity, accuracy, and economics.

MODULE 3: Injection Moulding & Mould Design (7 hours)

Overview of plastic processing methods. Injection moulding fundamentals. Types of injection moulding machines. Injection moulding cycle. Clamping systems. Feed system (runner & gates). Ejection systems. Cooling systems. Shrinkage considerations. Process defects & remedies.

Industrial Case Study: Injection Moulding – Plastic Buckets
Study of mould layout, gating system, cooling challenges, shrinkage, and defects like sink marks & warpage.

MODULE 4: Compression & Transfer Moulding (7 hours)

Compression moulding fundamentals. Mould types. Bulk factor. Moulding cycle. Tooling considerations. Applications.

Transfer moulding fundamentals. Pot & plunger systems. Advantages & limitations. Tooling considerations. Comparison with compression moulding.

Industrial Case Study: Transfer Moulding – Electrical Switchgear Components / Melamine Handles
Practical application involving thermosetting plastics requiring dimensional stability and surface finish.

MODULE 5: Blow Moulding & Industrial Products (8 hours)

Blow moulding fundamentals. Extrusion blow moulding. Injection blow moulding. Stretch blow moulding. Parison formation. Blow ratio. Product design considerations. Cooling. Defects & remedies.

Industrial Case Study: Blow Moulding – Plastic Bottles
Study of parison control, wall thickness variation, shrinkage, and defects like flash & uneven thickness.

Text Books

1. Ivana Suchy, *Handbook of Die Design*, McGraw-Hill Education.
2. R. G. W. Pye, *Injection Mould Design*, Longman Scientific & Technical.
3. Mikell P. Groover, *Fundamentals of Modern Manufacturing: Materials, Processes and Systems*, John Wiley & Sons.
4. Serope Kalpakjian and Steven Schmid, *Manufacturing Engineering and Technology*, Pearson Education.

Reference Books

1. Vukota Boljanovic**,** *Sheet Metal Forming Processes and Die Design*, Industrial Press Inc.
2. Dominick V. Rosato and Donald V. Rosato, *Injection Moulding Handbook*, Springer.
3. J. A. Brydson, *Plastics Materials*, Butterworth-Heinemann.
4. P. C. Sharma, *Production Engineering*, S. Chand & Company Ltd.
5. ASTM Standards**,** *Standards for Metal Forming and Plastic Processing*, ASTM International.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Sheet Metal Characteristics and Applications - Properties of sheet metals - Formability considerations - Industrial applications of sheet metal components - Advantages of sheet metal manufacturing	1
1.2	Press Working Operations - Blanking- Piercing- Bending- Forming operations- Cutting mechanisms	1
1.3	Cutting Mechanism & Terminology- Shearing process- Fracture zones- Burr formation- Die clearance concept- Press working terminology	2
1.4	Types of Dies & Press Tools - Single-stage dies- Compound dies- Progressive dies- Combination dies	1
1.5	Die Materials & Tooling Considerations-Tool steels- Heat treatment basics- Wear resistance & hardness	1
1.6	Industrial Case Study: Progressive Tool for Door Hinges Discussion includes: Strip layout design, Sequence of operations Material utilization- Production advantages	1
	Module 2	**7**
2.1	Strip Layout & Percentage Utilization- Strip design fundamentals- Material economy- Nesting strategies- Percentage utilization	2
2.2	Cutting Force Analysis - Shearing force fundamentals- Factors affecting cutting force- Force estimation principles	1
2.3	Press Tonnage Calculation- Press capacity selection- Safety factors- Practical design considerations	1
2.4	Die Clearance & Standards - Clearance selection- Effect on tool life- Effect on product quality- Design standards	1

2.5	Bending Force, Developed Length & Spring Back- Bending mechanics -Developed length- Spring back phenomenon	1
2.6	Industrial Case Study: Compound vs Progressive Die – Sheet Metal Hinges / Brackets: Discussion includes: Productivity comparison, Cost implications, Accuracy considerations	1
	Module 3	**7**
3.1	Overview of Plastic Processing Methods- Thermoplastics vs Thermosets- Plastic manufacturing techniques- Selection criteria	1
3.2	Injection Moulding Fundamentals - Injection moulding cycle- Stages of moulding- Process principles	1
3.3	Injection Moulding Machines - Types of machines- Clamping systems- Shot capacity- Machine specifications	1
3.4	Injection Mould Design Elements- Feed system (runner & gates)- Ejection systems- Cooling systems -Parting line considerations	2
3.5	Shrinkage & Process Defects -Shrinkage behavior- Sink marks- Warpage- Remedies	1
3.6	Industrial Case Study: Injection Moulding – Plastic Buckets Discussion includes: Gating system challenges, Cooling design importance, Shrinkage effects, Typical defects	1
	Module 4	**7**
4.1	Compression Moulding Fundamentals- Process principle- Moulding cycle- Applications	1
4.2	Compression Mould Design - Mould components- Bulk factor- Flash control- Defects	1
4.3	Transfer Moulding Fundamentals - Pot & plunger system- Material flow mechanism- Comparison with compression moulding	2
4.4	Transfer Mould Tooling Considerations- Runner & gate design- Advantages- Limitations- Defects	1
4.5	Comparison of Thermoset Moulding Processes - Process selection- Industrial considerations	1
4.6	Industrial Case Study: Transfer Moulding – Electrical Switchgear Components / Melamine Handles: Discussion includes: Dimensional stability needs- Surface finish requirements- Tooling challenges	1
	Module 5	**8**
5.1	Blow Moulding Fundamentals - Process principle- Parison formation- Blow ratio	2
5.2	Extrusion Blow Moulding- Working principle- Applications- Advantages	2
5.3	Injection Blow Moulding - Process mechanism- Comparison with extrusion method	1
5.4	Product Design Considerations- Wall thickness control- Cooling- Shrinkage- Defects	1
5.5	Blow Moulding Defects & Remedies- Flash- Uneven thickness- Warpage	1
5.6	Industrial Case Study: Blow Moulding – Plastic Bottles Discussion includes: Parison control, Thickness variation, Common industrial defects	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Explain various sheet metal press operations with neat sketches.
2. Describe the cutting mechanism involved in blanking and piercing.
3. Discuss different types of dies used in press working.
4. Explain the role of die clearance in sheet metal operations.
5. Explain progressive dies with reference to door hinge manufacturing.

Course Outcome 2 (CO2):

1. Explain strip layout design and its importance in press tool design.
2. Derive an expression for cutting force in blanking operation.
3. Explain press tonnage calculation with suitable example.
4. Discuss methods for reducing cutting forces.
5. Explain spring back phenomenon and compensation techniques.

Course Outcome 3 (CO3):

1. Explain injection moulding process with neat sketch.
2. Discuss types of injection moulding machines.
3. Explain feed system and gating design considerations.
4. Explain cooling system design in injection moulds.
5. Explain injection moulding of plastic buckets as an industrial case study.

Course Outcome 4 (CO4):

1. Explain compression moulding process with neat sketch.
2. Explain transfer moulding process with neat sketch.
3. Compare compression and transfer moulding processes.
4. Discuss tooling considerations in transfer moulds.
5. Explain transfer moulding of electrical components / melamine handles.

Course Outcome 5 (CO5)

1. Explain blow moulding process with neat sketch.
2. Discuss extrusion blow moulding process.
3. Discuss injection blow moulding process.
4. Explain product design considerations in blow moulding.
5. Explain blow moulding of plastic bottles as an industrial case study.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

EIGHT SEMESTER B TECH DEGREE EXAMINATION, APRIL 2028

Course Code: **B24ME4P59**

Course Name: **METAL FORMING AND INJECTION MOULDING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Differentiate between blanking and piercing.
2. Define die clearance.
3. What is percentage utilization?
4. Define spring back.
5. List stages of injection moulding cycle.
6. Define shot capacity.
7. Differentiate compression and transfer moulding.
8. Define bulk factor.
9. Define parison.
10. List two blow moulding defects.

PART B

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

Module 1

11 a. Explain sheet metal press operations and cutting mechanism. (7 marks)

b. Explain progressive dies with industrial example (door hinge). (7 marks)

OR

12 Describe the cutting mechanism involved in blanking and piercing operations. (14 marks)

Module 2

13 Explain strip layout design and percentage utilization with door hinge example. (14 marks)

OR

14 Explain cutting force and press tonnage calculation in press tool design. (14 marks)

Module 3

15 Describe the injection moulding process and discuss mould design elements. (14 marks)

OR

16 Discuss injection moulding defects and remedies with reference to plastic bucket manufacturing. (14 marks)

Module 4

17 Explain the compression moulding process with neat sketch. (14 marks)

OR

18 Describe the transfer moulding process and discuss its industrial applications. (14 marks)

Module 5

19 Explain the blow moulding process and discuss types of blow moulding methods. (14 marks)

OR

20 Discuss product design considerations and defects in blow moulding with reference to plastic bottle manufacturing (14 marks)

B24ME4P61	SIX SIGMA AND QUALITY MANAGEMENT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Quality management has become a key strategic requirement for organizations aiming to improve productivity, reduce defects, and enhance customer satisfaction. Methodologies such as Six Sigma provide structured approaches for continuous improvement and data-driven decision making in manufacturing and service industries. This course introduces mechanical engineering students to the principles of quality management, statistical quality control, and the Six Sigma improvement methodology. The course content is aligned with professional certification frameworks such as the American Society for Quality programs including Six Sigma Green Belt Certification and Six Sigma Black Belt Certification, enabling students to understand industry practices in quality improvement and operational excellence.

Prerequisites

Nil

Course Outcomes

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

CO 1	Define and describe fundamental concepts of quality management, cost of quality, and continuous improvement in industrial systems. (Cognitive Knowledge Level: Understand).
CO 2	Explain statistical quality control concepts and interpret process variation and control charts used in manufacturing processes. (Cognitive Knowledge Level: Understand).
CO 3	Apply the Six Sigma DMAIC methodology to identify and solve quality-related problems in production systems. (Cognitive Knowledge Level: Apply)
CO 4	Apply basic quality improvement tools such as Pareto charts, cause-and-effect diagrams, histograms, and process mapping for process analysis (Cognitive Knowledge Level: Apply)
CO 5	Explain the role of quality management systems, Lean Six Sigma practices, and organizational strategies for continuous quality improvement (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	1	–	–	–	–	–	–	–	–	–
CO 2	2	3	–	–	1	–	–	–	–	–	–
CO 3	2	3	2	–	1	–	–	–	–	–	–
CO 4	2	2	2	–	1	–	–	–	–	–	–
CO 5	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Introduction to Quality Management (7 Hours)

Concept of quality and quality management - quality evolution and importance in manufacturing, quality dimensions, cost of quality - principles of Total Quality Management – customer focus, continuous improvement, employee involvement – Quality Function Deployment (QFD): concept, importance, House of Quality and its role in translating customer requirements into technical specifications - quality standards and frameworks – ISO quality management systems, process approach, documentation & quality audits.

Module 2: Statistical Quality Control (7 Hours)

Variation in manufacturing processes – common causes and assignable causes, process capability concepts – statistical process control – control charts for variables and attributes, process capability indices – acceptance sampling – sampling plans, operating characteristic curves, inspection and quality assurance in production systems - Software tools.

Module 3: Six Sigma Methodology (7 Hours)

Introduction to Six Sigma – evolution of Six Sigma, objectives, benefits and organizational roles – roles of Green Belt, Black Belt and Champions – Six Sigma project selection – DMAIC methodology – define phase, voice of customer and problem identification – measure phase, data collection and performance metrics – analyze phase, root cause analysis – improvement and control phases for sustaining process improvements.

Module 4: Quality Improvement Tools and Techniques (7 Hours)

Basic quality tools – check sheets, histograms, Pareto analysis, cause and effect diagrams, scatter diagrams, control charts – problem solving approaches and root cause analysis, brainstorming, 5 Why analysis – Failure Mode and Effects Analysis (FMEA), concept, risk priority number and applications in manufacturing – process mapping and value stream mapping, identification of process bottlenecks and waste – design for quality concepts, introduction to design for Six Sigma and robust product and process design.

Module 5: Six Sigma Implementation and Emerging Practices (8 Hours)

Six Sigma implementation strategies – Six Sigma deployment strategies – project management in quality improvement – Lean principles and Lean Six Sigma integration – benchmarking and continuous improvement – digital quality management systems – emerging technologies in quality management, data analytics, artificial intelligence and Industry 4.0 applications in process quality improvement. - Case Studies.

Textbooks

1. Montgomery D. C., *Introduction to Statistical Quality Control*, Wiley.
2. Pande P., Neuman R. and Cavanagh R., *The Six Sigma Way*, McGraw Hill.
3. Hemant Urdhwareshe, *Six Sigma for Business Excellence: Approach, Tools and Applications,* Pearson Education India.

Reference Books

1. Evans J. R. and Lindsay W., *Managing for Quality and Performance Excellence*, Cengage Learning.

2. Pyzdek T. and Keller P., *The Six Sigma Handbook*, McGraw Hill.
3. Peter S. Pande, Robert P. Neuman and Roland R. Cavanagh, *The Six Sigma Way,* McGraw-Hill.
4. Besterfield, D. H., Besterfield-Michna, C., Besterfield, G. H., & Besterfield-Sacre, M. (2011). *Total quality management (3rd ed.)*. Pearson Education India.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Concept of quality and quality management – evolution of quality, importance in manufacturing, quality dimensions	2
1.2	Cost of quality – prevention, appraisal and failure costs – impact on productivity	2
1.3	Principles of total quality management – customer focus, continuous improvement, employee involvement	1
1.4	Quality Function Deployment (QFD): concept, importance, House of Quality and its role in translating customer requirements into technical specifications	1
1.5	Quality standards and frameworks – ISO quality management systems, documentation and quality audits	1
	Module 2	**7**
2.1	Process variation – common causes and assignable causes – introduction to statistical quality control	2
2.2	Statistical process control – control charts for variables and attributes	2
2.3	Process capability analysis – Cp and Cpk indices	2
2.4	Acceptance sampling – sampling plans and operating characteristic curves, Software tools.	1
	Module 3	**7**
3.1	Introduction to Six Sigma – objectives, benefits and organizational roles, roles of Green Belt, Black Belt and Champions	2
3.2	DMAIC methodology – define phase and voice of customer	2
3.3	DMAIC methodology – measure and analyze phases, data collection and root cause analysis	2
3.4	DMAIC methodology – improve and control phases for sustaining improvements	1
	Module 4	**7**
4.1	Basic quality tools – check sheets, histograms, Pareto analysis	2
4.2	Cause and effect diagrams, scatter diagrams and control charts	2
4.3	Failure Mode and Effects Analysis (FMEA) and process mapping	2
4.4	Value stream mapping and design for quality concepts	1
	Module 5	**8**
5.1	Six Sigma implementation, deployment-project management in quality improvement.	2
5.2	Lean principles and Lean Six Sigma integration	2
5.3	Benchmarking and continuous improvement strategies	2

5.4	Digital quality management systems – data analytics and Industry 4.0 applications in quality management	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1)

1. Define quality and quality management.
2. What is meant by cost of quality? List its components.
3. Explain the concept of Total Quality Management and discuss its principles with suitable examples.
4. Discuss the different components of the cost of quality and explain their impact on organizational performance.

Course Outcome 2 (CO2)

1. Distinguish between common causes and assignable causes of variation.
2. What is Statistical Process Control (SPC)?
3. Explain the concept of Statistical Process Control and describe control charts used for process monitoring.
4. Discuss acceptance sampling and explain the concept of operating characteristic (OC) curves.

Course Outcome 3 (CO3):

1. Define Six Sigma.
2. What is the DMAIC cycle?
3. Explain the DMAIC methodology used in Six Sigma projects with suitable examples.
4. Describe the Define and Measure phases of Six Sigma with suitable industrial examples.

Course Outcome 4 (CO4):

1. What is a Pareto chart?
2. What is a cause-and-effect diagram?
3. Explain the seven basic quality tools and their importance in quality improvement.
4. Explain the steps involved in conducting Failure Mode and Effects Analysis (FMEA) for product reliability improvement.

Course Outcome 5 (CO5)

1. What is Lean Six Sigma?
2. Define benchmarking.
3. Discuss the implementation strategy of Six Sigma in manufacturing organizations.
4. Explain the concept of Lean Six Sigma and its benefits in improving operational efficiency.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

EIGHTH SEMESTER B TECH DEGREE EXAMINATION, MAY 2028

Course Code: **B24ME4P61**

Course Name: **SIX SIGMA AND QUALITY MANAGEMENT**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. State the principles of Total Quality Management (TQM).
2. What is the role of ISO quality standards in manufacturing?
3. Define process capability index.
4. What are control charts?
5. What is meant by Voice of Customer (VOC)?
6. What are the roles of Green Belt and Black Belt?
7. Define histogram.
8. What is Failure Mode and Effects Analysis (FMEA)?
9. What is continuous improvement?
10. What is digital quality management?

PART B

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

Module 1

11. Discuss the different components of the cost of quality and explain their impact on organizational performance. (14 marks)

OR

12. Describe the structure and implementation of ISO quality management systems in manufacturing organizations. (14marks)

Module 2

13. The specification limits for a shaft diameter are 20 ± 0.05 mm. The process has a mean of 20.01 mm and standard deviation of 0.01 mm.
Calculate Cp and Cpk. Comment on the process capability. (14marks)

OR

14. Discuss acceptance sampling and explain the concept of operating characteristic (OC) curves. (14marks)

Module 3

15. Describe the Define and Measure phases of Six Sigma with suitable industrial examples. (14marks)

OR

16. A manufacturing process produces 5000 units per day. During inspection, 120 defects are found. Each unit has 4 defect opportunities.
Calculate:
    a. Defects per opportunity (DPO)
    b. Defects per million opportunities (DPMO)
    c. Sigma level (approximate). (14marks)

Module 4

17. Explain the seven basic quality tools and their importance in quality improvement. (14marks)

OR

18. The following defects were observed in a production line during inspection:

Defect Type	Number of Defects
Surface scratch	45
Dimensional error	30
Assembly defect	15
Paint defect	10

    a. Construct a Pareto analysis.
    b. Identify the most critical defect category.
    c. Explain the steps involved in conducting Failure Mode and Effects Analysis (FMEA) for product reliability improvement.

(14marks)

Module 5

19. Explain the concept of Lean Six Sigma and its benefits in improving operational efficiency. (14 marks)

OR

20. A company produces 20,000 units per month with a defect rate of 2%. By implementing Six Sigma improvement methods, the defect rate reduces to 0.5%.
Calculate the number of defective units before and after improvement.
Discuss the impact of quality improvement on productivity and cost. (14 marks)

B24ME4P62	OCCUPATIONAL HEALTH AND SAFETY	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Occupational Health and Safety (OHS) is a critical aspect of engineering practice that aims to prevent workplace accidents, protect worker health, and ensure sustainable industrial operations. Engineers play a significant role in identifying hazards, assessing risks, and implementing safety measures during design, construction, and operation of industrial systems. This course introduces students to fundamental principles of occupational health and safety, hazard identification, risk assessment, engineering safety controls, and emergency management. The syllabus is aligned with internationally recognized safety certification frameworks to provide students with industry-relevant competencies in safety engineering, risk management, and regulatory compliance.

Prerequisites

Nil

Course Outcomes

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

CO 1	Define fundamental concepts, standards, and legal frameworks related to occupational health and safety management. (Cognitive Knowledge Level: Remember).
CO 2	Explain hazard identification techniques and risk assessment methods used in industrial safety management. (Cognitive Knowledge Level: Understand).
CO 3	Apply engineering safety principles and hierarchy of controls to minimize risks in industrial systems. (Cognitive Knowledge Level: Apply)
CO 4	Apply occupational hygiene, ergonomics, and human factor principles for safer workplace design. (Cognitive Knowledge Level: Apply)
CO 5	Explain environmental safety practices, emergency preparedness, and safety management strategies in industrial operations. (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	1	–	–	–	1	–	–	–	–	–
CO 2	2	3	–	1	–	1	–	–	–	–	–
CO 3	2	3	2	–	1	1	–	–	–	–	–
CO 4	2	2	2	–	1	2	–	–	–	–	–
CO 5	1	2	–	–	–	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Foundations of Occupational Health and Safety (7 Hours)

Fundamentals of occupational health and safety – hazard, risk, accident, incident, near miss and exposure – safety by design and life cycle safety concepts – roles and responsibilities in workplace safety, employer, engineer, contractor and safety officer – legal frameworks and regulatory requirements – national and international safety standards, BIS, ANSI, ISO, NFPA and IEC – occupational health and safety management systems – PDCA cycle, ISO 45001 framework and integration with quality and environmental management systems.

Module 2: Hazard Identification and Risk Assessment (7 Hours)

Hazard identification methods – Job Safety Analysis, Job Hazard Analysis, Preliminary Hazard Analysis, HAZOP studies and Bow-Tie analysis – Failure Mode and Effects Analysis in safety engineering – qualitative and quantitative risk assessment methods – risk estimation using probability, severity and exposure – risk evaluation using ALARP principle – risk matrix and consequence analysis – accident investigation models – Domino theory, Swiss Cheese model and energy release theory – root cause analysis tools, fault tree analysis, event tree analysis, fishbone diagram and 5 Why technique.

Module 3: Technical Safety Engineering (8 Hours)

Hierarchy of safety controls – elimination, substitution, engineering controls, administrative controls and personal protective equipment – machinery safety and machine guarding – inspection and maintenance procedures – lockout tagout systems – safety of industrial equipment, pressure vessels, boilers, cranes and lifting equipment – fire and explosion safety – fire chemistry, detection and suppression systems, dust explosion prevention – electrical safety – earthing, bonding, insulation, circuit protection and relevant standards.

Module 4: Occupational Hygiene, Ergonomics and Human Factors (7 Hours)

Occupational hygiene principles – physical, chemical and biological hazards in industrial environments – workplace exposure limits, TLV, PEL and OEL – engineering controls for exposure reduction – ventilation systems, noise control and vibration isolation – ergonomics principles – anthropometry, workstation design and human machine interface – manual handling and prevention of musculoskeletal disorders.

Module 5: Environmental, Emergency and Professional Safety Practice (7 Hours)

Environmental health and safety principles – hazardous and non hazardous waste management – spill prevention and control – sustainable and green engineering practices – emergency preparedness and response planning – emergency organization structure, evacuation and shutdown procedures – disaster management and crisis communication – construction and project safety – excavation safety, working at height, scaffolding safety, confined spaces and permit to work systems.- safety documentation and reporting – safety audits, inspections and safety performance indicators – analysis of major industrial accidents and lessons learned.- Case Studies.

Textbooks

1. Goetsch, D. L., *Occupational Safety and Health for Technologists, Engineers and Managers*. Pearson Education.

2. Mistry, K. U., & Bhandari, R. M., *Industrial Safety and Environment*. Charotar Publishing House.
3. Deshmukh, L. M., *Industrial Safety Management*. Tata McGraw-Hill Education.

Reference Books

1. Jain, R. K., & Rao, S. S., *Handbook of Industrial Safety*. Khanna Publishers.
2. Brauer, R. L., *Safety and Health for Engineers*. Wiley.
3. Friend, M. A., & Kohn, J. P., *Fundamentals of Occupational Safety and Health*. Bernan Press.
4. Government of India, *Occupational Safety, Health and Working Conditions Code*. Government of India Publications.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Fundamentals of occupational health and safety – hazard, risk, accident, incident, near miss and exposure – safety by design and life cycle safety	2
1.2	Roles and responsibilities in workplace safety – employer, engineer, contractor and safety officer – due diligence and duty of care	2
1.3	Safety legislations and standards – national and international frameworks, BIS, ANSI, ISO, NFPA and IEC	2
1.4	OHS management systems – PDCA cycle, ISO 45001 framework and integration with quality and environmental management systems	1
	Module 2	**7**
2.1	Hazard identification techniques – Job Safety Analysis, Job Hazard Analysis, Preliminary Hazard Analysis	2
2.2	Risk assessment methods – qualitative and quantitative risk assessment, probability, severity and exposure	2
2.3	Risk evaluation – ALARP principle, risk matrix and consequence analysis	2
2.4	Incident investigation and root cause analysis – Domino model, Swiss Cheese model, fault tree analysis and 5 Why technique	1
	Module 3	**8**
3.1	Hierarchy of safety controls – elimination, substitution, engineering and administrative controls, personal protective equipment	2
3.2	Machinery safety – machine guarding, inspection and lockout/tagout procedures	2
3.3	Safety of industrial equipment – pressure vessels, boilers, cranes and lifting equipment	2

3.4	Fire, explosion and electrical safety – fire chemistry, detection and suppression systems, earthing, bonding and circuit protection	2
	Module 4	**7**
4.1	Occupational hygiene – physical, chemical and biological hazards – exposure limits such as TLV, PEL and OEL	2
4.2	Engineering controls – ventilation systems, noise reduction and vibration isolation	2
4.3	Ergonomics – anthropometry, workstation design and human–machine interface	3
	Module 5	**7**
5.1	Environmental health and safety – hazardous and non-hazardous waste management, spill prevention and sustainable practices	2
5.2	Emergency preparedness – emergency response plans, evacuation procedures and shutdown operations	2
	Construction and project safety – excavation, working at height, scaffolding, confined spaces and permit-to-work systems	1
5.3	Safety documentation – safety audits, inspections and performance indicators	1
5.4	Industrial safety case studies and lessons learned from major accidents	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1)

1. Define hazard and risk.
2. What is meant by a near miss?
3. Explain the principles of occupational health and safety and discuss the responsibilities of employers and engineers in ensuring workplace safety.
4. Discuss the structure and implementation of an Occupational Health and Safety Management System based on ISO 45001.

Course Outcome 2 (CO2)

1. What is Job Safety Analysis (JSA)?
2. Define HAZOP study.
3. Explain different hazard identification techniques used in industrial safety management.
4. Explain accident investigation models such as Domino theory and Swiss Cheese model with suitable diagrams.

Course Outcome 3 (CO3):

1. State the hierarchy of controls in safety engineering.
2. What is machine guarding?

3. Explain the hierarchy of safety controls with suitable industrial examples.
4. Discuss fire and explosion hazards in industrial environments and describe the methods used for fire detection and suppression.

Course Outcome 4 (CO4):

1. What is occupational hygiene?
2. Define TLV (Threshold Limit Value).
3. Explain the principles of occupational hygiene and methods used to control workplace hazards.
4. Discuss ergonomics in workplace design and explain how poor ergonomic design affects worker health and productivity.

Course Outcome 5 (CO5)

1. What is Environmental Health and Safety (EHS)?
2. Define hazardous waste.
3. Explain the importance of emergency preparedness and response planning in industrial safety management.
4. Discuss the procedures involved in safety audits and inspections in industrial organizations.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

EIGHTH SEMESTER B TECH DEGREE EXAMINATION, MAY 2028

Course Code: **B24ME4P62**

Course Name: **OCCUPATIONAL HEALTH AND SAFETY**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What is due diligence in occupational safety?
2. List any four international safety standards.
3. What is meant by a risk matrix?
4. What is fault tree analysis?
5. What is lockout/tagout?
6. Define fire triangle.
7. What are musculoskeletal disorders (MSDs)?
8. What is a confined space?
9. What is spill control?
10. Define safety performance indicators.

PART B

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

Module 1

11. Discuss the structure and implementation of an Occupational Health and Safety Management System based on ISO 45001. (14 marks)

OR

12. Explain the concept of safety by design and life cycle safety with examples from engineering systems. (14 marks)

Module 2

13. Explain accident investigation models such as Domino theory and Swiss Cheese model with suitable diagrams. (14 marks)

OR

14. Explain different hazard identification techniques used in industrial safety management. (14 marks)

Module 3

15. A machine operates at high speed and poses risks of mechanical failure and operator injury.
    - Identify possible hazards associated with the machine.
    - Suggest engineering and administrative safety controls to mitigate the risks.

    (14 marks)

OR

16. Discuss fire and explosion hazards in industrial environments and describe the methods used for fire detection and suppression. (14 marks)

Module 4

17. A worker repeatedly lifts 25 kg loads during an 8-hour shift.
    - Identify potential ergonomic hazards.
    - Suggest engineering and administrative measures to reduce musculoskeletal disorders. (14 marks)

OR

18. Discuss ergonomics in workplace design and explain how poor ergonomic design affects worker health and productivity. (14 marks)

Module 5

19. A chemical plant stores 5000 liters of flammable solvent.
    i. Identify potential environmental and safety risks.
    ii. Propose emergency response and spill control measures to manage the situation.

    (14 marks)

OR

20. Discuss the procedures involved in safety audits and inspections in industrial organizations. (14 marks)

B24ME4P63	MEP SYSTEMS AND MANAGEMENT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Mechanical, Electrical and Plumbing (MEP) systems play a critical role in the functioning of modern buildings and industrial facilities. Mechanical engineers are increasingly involved in the design, coordination, installation and management of these systems. This course introduces the fundamentals of MEP services including HVAC systems, electrical distribution, plumbing and fire protection systems, along with their integration in buildings and manufacturing facilities. The course also emphasizes project coordination, installation practices, cost estimation and maintenance aspects of MEP projects, preparing students for roles in building services engineering and infrastructure management.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the fundamentals of Mechanical, Electrical and Plumbing (MEP) systems and interpret basic building service drawings and coordination requirements in construction projects. (Cognitive Knowledge Level: Understand).
CO 2	Apply principles of HVAC systems to estimate cooling load and develop basic duct layouts for building applications. (Cognitive Knowledge Level: Apply).
CO 3	Apply the principles of electrical power distribution in buildings to prepare basic single-line diagrams and perform simple lighting design calculations. (Cognitive Knowledge Level: Apply)
CO 4	Apply principles of plumbing and fire protection systems to perform pipe sizing calculations and prepare basic plumbing layouts. (Cognitive Knowledge Level: Apply)
CO 5	Explain installation practices, testing, commissioning, project planning and maintenance aspects involved in MEP system implementation. (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	1	–	–	2	–	–	–	–	–	1
CO 2	3	2	2	–	2	1	–	–	–	–	–
CO 3	3	2	2	–	2	1	–	–	–	–	–
CO 4	2	2	2	–	1	2	1	–	–	–	–
CO 5	2	1	1	–	1	1	1	2	2	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Fundamentals of MEP Systems and Project Coordination (6 Hours)

Introduction to MEP systems in buildings and industrial facilities. Role and integration of mechanical, electrical and plumbing systems in modern infrastructure. Basic engineering drawings and symbols used in MEP layouts. Interpretation of building service drawings and overview of building services design. MEP project workflow and coordination among different disciplines. Safety standards, building regulations and sustainable practices in MEP systems.

Self-Study: Students will identify major MEP components from a typical building plan and prepare a simple MEP layout or short report highlighting the importance of MEP coordination in building projects.

Module 2: Mechanical Systems – HVAC Design and Management (8 Hours)

Fundamentals of heating, ventilation and air conditioning (HVAC). Types of HVAC systems including split systems, centralized systems, variable refrigerant flow (VRF) systems and chiller-based systems. Cooling load estimation concepts and basic methods. Principles of duct design and airflow management. Mechanical equipment used in HVAC systems such as pumps, compressors, fans and cooling towers. Criteria for HVAC system selection, energy efficiency considerations and basic maintenance requirements.

Self-Study: Students will perform a simple cooling load estimation for a small space and prepare a basic HVAC duct layout.

Module 3: Electrical Systems in Buildings and Industrial Facilities (7 Hours)

Overview of electrical power generation and distribution in buildings. Transformers, switchgear, distribution boards and electrical panels. Preparation and interpretation of single line diagrams. Lighting design principles and energy-efficient lighting systems. Motor control systems used in manufacturing plants. Electrical protection systems including circuit breakers, grounding and earthing. Electrical load management and backup power planning in buildings and industries. Lightning management systems.

Self-Study: Students will prepare a basic single line diagram for a building electrical system and perform a simple lighting design calculation.

Module 4: Plumbing and Fire Protection Systems (7 Hours)

Water supply systems in buildings and industrial facilities. Pipe materials and installation practices. Water distribution and storage systems. Drainage and sewage systems. Fire protection systems including sprinklers, hydrants, alarms and fire pumps. Plumbing requirements in industrial facilities. Maintenance considerations and safety regulations related to plumbing and fire protection systems. Firefighting management systems.

Self-Study: Students will perform basic pipe sizing calculations and prepare a simple plumbing layout for a building.

Module 5: MEP Installation, Project Management and Facility Management (8 Hours)

Manufacturing and fabrication of MEP components such as ducts, pipes, cable trays and electrical panels. Installation practices and site coordination among MEP systems. Testing, commissioning and quality control procedures. Basics of MEP project planning, scheduling and cost estimation. Procurement of MEP equipment and materials. Documentation and

reporting in MEP projects. Introduction to facility management, operation and maintenance of MEP systems.

Self-Study: Students will prepare a simple installation sequence or cost estimation exercise for a small MEP project.

Textbooks

1. W. Grondzik, A. Kwok, B. Stein and J. Reynolds, *Mechanical and Electrical Equipment for Buildings*, Wiley.
2. F. C. McQuiston, J. Parker and J. Spitler, *Heating, Ventilating and Air Conditioning: Analysis and Design*, Wiley.

Reference Books

1. S. C. Rangwala, *Water Supply and Sanitary Engineering*, Charotar Publishing House.
2. Herman and Rajiv Choudhary, *Electrical Design, Estimating and Costing*, S. Chand Publishing.
3. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), *ASHRAE Handbook – HVAC Fundamentals*.
4. Bureau of Indian Standards, *National Building Code of India – Building Services*.
5. R. Dodge Woodson, *Mechanical and Electrical Systems in Buildings*, McGraw-Hill.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**6**
1.1	Evolution and scope of logistics and supply chain management – definition, importance, role in manufacturing and service sectors	2
1.2	Supply chain structure and flows – suppliers, manufacturers, distributors, retailers – material, information and financial flows	2
1.3	Logistics drivers – facilities, inventory, transportation and information – coordination in supply chains	1
1.4	Logistics performance measurement – customer service levels, logistics costs and key performance indicators	1
	Module 2	**8**
2.1	Fundamentals of HVAC systems and types of systems including split, centralized, VRF and chiller-based systems.	2
2.2	Cooling load estimation concepts and criteria for HVAC system selection.	2
2.3	Duct design principles, airflow management and HVAC equipment such as pumps, compressors, fans and cooling towers.	2
2.4	Energy efficiency considerations and operation and maintenance of HVAC systems.	2
	Module 3	**7**
3.1	Electrical power generation and distribution in buildings;	2

	transformers, switchgear and distribution panels.	
3.2	Preparation and interpretation of single line diagrams.	2
3.3	Lighting design principles and energy-efficient lighting systems.	1.5
3.4	Motor control systems, electrical protection, grounding and backup power planning. Lightning management systems.	1.5
	Module 4	**7**
4.1	Water supply systems, pipe materials and installation practices.	2
4.2	Water distribution networks, storage systems and drainage systems.	2
4.3	Fire protection systems including sprinklers, hydrants and fire pumps. Firefighting management systems	2
4.4	Safety regulations and maintenance considerations in plumbing and fire systems.	1
	Module 5	**8**
5.1	Manufacturing and fabrication of MEP components such as ducts, pipes, cable trays and panels.	2
5.2	Installation methods and site coordination among MEP systems.	2
5.3	Testing, commissioning and quality control of MEP installations.	2
5.4	Project planning, cost estimation, procurement and facility management of MEP systems.	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1)

1. Define MEP systems and explain their importance in modern buildings.
2. List common symbols used in MEP drawings and explain their significance.
3. Explain the role of mechanical, electrical and plumbing systems in modern buildings and discuss their integration in building services.
4. Discuss the importance of MEP coordination in construction projects and explain.

Course Outcome 2 (CO2)

1. Define cooling load in HVAC systems.
2. Distinguish between split and centralized HVAC systems.
3. Explain the working principle and classification of HVAC systems used in buildings.
4. Describe the cooling load estimation process and explain the factors affecting cooling load in a building.

Course Outcome 3 (CO3):

1. What is a single-line diagram in electrical distribution?
2. State the function of transformers in building electrical systems.
3. Explain the electrical power distribution system used in buildings with a neat diagram.

4. Describe the preparation of a single-line diagram and explain its importance in electrical system design.

Course Outcome 4 (CO4):

1. List the main components of a building water supply system.
2. What are the commonly used pipe materials in plumbing systems?
3. Explain the design and components of water supply systems in buildings.
4. Describe drainage and sewage systems used in residential and commercial buildings..

Course Outcome 5 (CO5)

1. What is testing and commissioning in MEP projects?
2. Define project scheduling in MEP installation.
3. Explain the manufacturing and fabrication processes used for MEP components such as ducts and pipes.
4. Discuss installation practices and coordination required during MEP system implementation in buildings.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

EIGHTH SEMESTER B TECH DEGREE EXAMINATION, MAY 2028

Course Code: **B24ME4P63**

Course Name: **MEP SYSTEMS AND MANAGEMENT**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the concept of MEP coordination? Why is it important in construction projects?
2. State the importance of safety standards in MEP installations.
3. Explain the main components of an HVAC system?
4. Mention two factors affecting HVAC system selection.
5. What is meant by electrical grounding?
6. List two types of electrical protection devices used in buildings.
7. Explain the purpose of a drainage system in buildings?
8. Mention two types of fire protection systems used in buildings.
9. Outline the major cost components in MEP projects?
10. State the importance of maintenance in MEP systems.

PART B

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

Module 1

11. Discuss the importance of MEP coordination in construction projects and explain the role of MEP engineers in project execution. (14 marks)

OR

12. Explain safety standards and sustainable practices followed in MEP system design and installation. (14marks)

Module 2

13. Describe the cooling load estimation process and explain the factors affecting cooling load in a building. (14marks)

OR

14. Explain the principles of duct design and airflow management in HVAC systems. (14marks)

Module 3

15. Explain the electrical power distribution system used in buildings with a neat diagram. (14marks)

OR

16. Describe the preparation of a single-line diagram and explain its importance in electrical system design. (14marks)

Module 4

17. Design a basic plumbing layout for a residential building. (14marks)

OR

18. Explain the working principles and components of fire protection systems such as sprinklers and hydrants. (14marks)

Module 5

19. Prepare a basic cost estimation outline for a small MEP installation project. (14 marks)

OR

20. Explain the stages involved in testing, commissioning and maintenance of MEP systems. (14 marks)

B24ME4P64	PIPING DESIGN AND MANUFACTURING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Piping systems are essential components in industrial sectors such as oil and gas, power plants, chemical processing and manufacturing industries. Mechanical engineers play a key role in the design, fabrication, installation and maintenance of these systems. This course introduces the fundamentals of piping engineering including piping components, materials, design standards, pipe routing, stress considerations and manufacturing processes. It also covers fabrication practices, installation procedures, inspection methods and project aspects involved in piping systems, preparing students for entry-level roles in piping design and fabrication industries.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the fundamentals of piping systems, components, materials and standards used in industrial piping applications. (Cognitive Knowledge Level: Understand).
CO 2	Apply basic principles of piping layout and routing to interpret piping drawings and prepare simple piping layouts for process systems. (Cognitive Knowledge Level: Apply).
CO 3	Apply basic concepts of piping stress and pipe support systems to accommodate thermal expansion and operational loads. (Cognitive Knowledge Level: Apply)
CO 4	Explain manufacturing and fabrication processes used for pipes and piping components in industrial applications. (Cognitive Knowledge Level: Understand)
CO 5	Explain installation practices, inspection methods and project aspects involved in piping system implementation. (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	1	–	–	1	–	–	–	–	–	1
CO 2	3	2	2	–	2	–	–	–	–	–	–
CO 3	3	2	2	–	1	1	–	–	–	–	–
CO 4	2	1	1	–	1	–	–	–	–	–	–
CO 5	2	1	1	–	1	1	1	2	2	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Fundamentals of Piping Systems (6 Hours)

Introduction to piping engineering and applications in process industries such as oil and gas, power plants and chemical plants. Piping terminology and components including pipes, fittings, flanges, valves and supports. Piping materials and criteria for material selection. Introduction to piping codes and standards used in industrial piping systems.

Self-study: Students will identify major piping components from industrial piping drawings and prepare a short report explaining their functions. A case example of piping systems used in a process plant will be discussed to understand piping layout and component integration.

Module 2: Piping Design and Layout (8 Hours)

Principles of pipe routing and piping layout in industrial plants. Plant layout considerations and piping arrangement in process units. Basic concepts of pipe sizing and fluid flow considerations. Piping drawings including piping and instrumentation diagrams (P&ID) and piping layout drawings. Introduction to basic piping drafting practices and design tools.

Self-study: Students will interpret a simple P&ID and prepare a basic piping layout for a small process unit, illustrating routing and component placement.

Module 3: Piping Stress and Support Systems (7 Hours)

Introduction to piping stress and thermal expansion in piping systems. Factors affecting piping stress and flexibility. Methods used to reduce piping stress and improve flexibility. Types of pipe supports and hangers used in industrial installations. Expansion joints, loops, anchors and guides used to accommodate thermal expansion.

Self-study: Students will analyze a simple piping system and identify suitable supports and expansion arrangements to accommodate thermal expansion.

Module 4: Piping Manufacturing and Fabrication (7 Hours)

Manufacturing processes used for pipes including seamless and welded pipes. Fabrication processes such as cutting, bending and welding of pipes. Pipe joining methods including welded, threaded and flanged joints. Welding techniques commonly used in piping fabrication. Inspection and testing methods used during piping fabrication and manufacturing.

Self-study: Students will study a typical pipe fabrication workflow and prepare a simple process chart showing cutting, welding and assembly steps used in piping fabrication.

Module 5: Installation, Inspection and Project Aspects (8 Hours)

Piping installation practices and site considerations in industrial plants. Alignment, erection and installation of piping systems. Quality control procedures and non-destructive testing methods used in piping systems. Hydrostatic testing and leak testing procedures. Safety practices during piping installation. Basics of piping project planning, documentation, cost considerations and maintenance practices.

Self-study: Students will prepare a basic installation sequence or inspection checklist for a piping system in a small industrial facility, highlighting testing and safety requirements.

Textbooks

1. Mohinder L. Nayyar, *Piping Handbook*, McGraw-Hill.
2. Donald C. Rennels and Hobart M. Hudson, *Pipe Flow: A Practical and Comprehensive Guide*, Wiley.

Reference Books

1. Peter Smith and R. W. Zappe, *Valve Selection Handbook*, Elsevier.
2. Charles Becht IV, *Process Piping: The Complete Guide to ASME B31.3*, ASME Press.
3. ASME B31.3 – *Process Piping Code* published by American Society of Mechanical Engineers.
4. *API Standards for Piping Systems* published by American Petroleum Institute.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**6**
1.1	Introduction to piping systems and applications in industries	2
1.2	Piping components: pipes, fittings, flanges, valves and supports	2
1.3	Piping materials and material selection criteria	1
1.4	Introduction to piping codes and standards	1
	Module 2	**8**
2.1	Pipe routing principles and plant layout considerations	2
2.2	Pipe sizing concepts and fluid flow considerations	2
2.3	Piping drawings: P&ID and piping layout drawings	2
2.4	Drafting practices and basic piping design tools	2
	Module 3	**7**
3.1	Introduction to piping stress and thermal expansion	2
3.2	Factors affecting piping stress and flexibility	2
3.3	Pipe supports and hangers used in piping systems	1.5
3.4	Expansion joints, loops and anchors	1.5
	Module 4	**7**
4.1	Manufacturing processes for pipes (seamless and welded)	2
4.2	Pipe fabrication processes: cutting and bending	2
4.3	Pipe joining methods and welding techniques	2
4.4	Inspection and testing methods in piping fabrication	1
	Module 5	**8**
5.1	Piping installation practices and site considerations	2
5.2	Quality control and non-destructive testing methods	2
5.3	Hydrostatic testing and safety practices	2
5.4	Project planning, documentation and maintenance	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1)

1. Define piping systems and state their industrial applications.
2. List the major components used in piping systems.
3. Explain the components and materials used in industrial piping systems.
4. Discuss the role of piping standards and codes in piping system design.

Course Outcome 2 (CO2)

1. Define pipe routing in piping design.
2. What is a piping and instrumentation diagram (P&ID)?
3. Explain the principles of pipe routing and layout in industrial plants.
4. Describe piping drawings such as P&ID and piping layout drawings with examples**.**

Course Outcome 3 (CO3):

1. What is thermal expansion in piping systems?
2. Define piping stress.
3. Explain the causes of piping stress and methods used to reduce piping stress.
4. Describe different types of pipe supports and their functions.

Course Outcome 4 (CO4):

1. Distinguish between seamless and welded pipes.
2. List common pipe fabrication processes.
3. Explain the manufacturing processes used for pipes.
4. Describe the fabrication processes used in piping systems.

Course Outcome 5 (CO5)

1. Define hydrostatic testing of piping systems.
2. What is non-destructive testing in piping inspection?
3. Explain the installation practices used for piping systems in industrial plants.
4. Discuss quality control and inspection procedures in piping installation.

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: **B24ME4P64**

Course Name: **PIPING DESIGN AND MANUFACTURING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. List out the common materials used for industrial pipes?
2. State the importance of piping standards and codes.
3. List factors affecting pipe sizing.
4. State two considerations in plant piping layout.
5. List two types of pipe supports.
6. State the purpose of expansion loops?
7. What are the commonly used pipe joining methods?
8. State two inspection methods used in piping fabrication.
9. Explain the major stages in piping installation?
10. State the importance of maintenance in piping systems.

PART B

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

Module 1

11. Explain the applications of piping systems in process industries. (14 marks)

OR

12. Discuss the role of piping standards and codes in piping system design. (14 marks)

Module 2

13. Explain the factors considered in pipe sizing and fluid flow in piping systems. (14 marks)

OR

14. Prepare a basic piping layout for a small process unit showing major piping routes. (14 marks)

Module 3

15. Describe different types of pipe supports and their functions. (14 marks)

OR

16. Explain the use of expansion loops and joints in piping systems. (14 marks)

Module 4

17. Explain inspection and testing methods used during piping fabrication. (14 marks)

OR

18. Prepare a simple fabrication sequence for pipe cutting, welding and assembly. (14 marks)

Module 5

19. Develop a basic inspection checklist for piping installation in an industrial plant. (14 marks)

OR

20. Explain the project management aspects involved in piping system implementation. (14 marks)

B24ME4P65	LOGISTICS AND SUPPLY CHAIN MANAGEMENT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Logistics and Supply Chain Management (LSCM) plays a vital role in modern manufacturing and service industries by ensuring efficient movement and storage of materials, information, and products from suppliers to customers. Mechanical engineers are increasingly required to understand logistics operations, distribution systems, and supply chain coordination to improve productivity and reduce operational costs. This course introduces the fundamental concepts of logistics, inventory planning, transportation, warehouse management, and global supply chain practices with emphasis on industrial applications and emerging digital technologies.

Prerequisites

Nil

Course Outcomes

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

CO 1	Define and describe the concepts, structure, and functions of logistics and supply chain management in industrial systems. (Cognitive Knowledge Level: Understand).
CO 2	Apply demand forecasting methods and interpret inventory management techniques used in supply chain operations. (Cognitive Knowledge Level: Apply).
CO 3	Apply principles of warehouse operations, storage systems, and material handling methods in logistics environments. (Cognitive Knowledge Level: Apply)
CO 4	Apply transportation planning concepts and select appropriate logistics network configurations for product distribution (Cognitive Knowledge Level: Apply)
CO 5	Explain global logistics practices, sustainability considerations, and emerging digital technologies in modern supply chains (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	1	–	–	–	1	–	–	–	–	–
CO 2	2	3	–	–	1	–	–	–	–	–	–
CO 3	2	2	2	–	1	–	–	–	–	–	–
CO 4	2	3	2	–	1	–	–	–	–	1	–
CO 5	1	2	–	–	–	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	40	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Introduction to Logistics and Supply Chain Management (7 Hours)

Evolution and scope of logistics and supply chain management – definition and importance of logistics, role of logistics in manufacturing and service sectors, supply chain structure and flows – components of supply chain, supplier manufacturer distributor retailer relationships, material information and financial flows – logistics drivers and performance measurement – facilities inventory transportation information drivers, logistics performance indicators, customer service and cost trade-offs.

Module 2: Demand Forecasting and Inventory Management (7 Hours)

Demand planning and forecasting – qualitative and quantitative forecasting methods, demand variability and bullwhip effect – inventory management concepts – functions and types of inventory, inventory costs and service levels – inventory control techniques – economic order quantity, reorder point and safety stock, ABC classification, vendor managed inventory and just in time practices.

Module 3: Warehouse and Distribution Management (7 Hours)

Warehouse operations and functions – receiving storage order picking and dispatch activities, role of distribution centers in supply chains – warehouse layout and material handling – storage systems, palletization, material handling equipment – order fulfillment processes – picking methods, packaging and unitization – warehouse automation and information systems – barcode systems, RFID technology, warehouse management systems.

Module 4: Transportation and Logistics Network Design (7 Hours)

Transportation systems and modes – road rail air sea and pipeline transportation characteristics, freight movement and carrier selection – transportation planning and routing – shipment consolidation, routing and scheduling – logistics network design – facility location considerations, distribution network configuration – third party logistics services – outsourcing logistics operations, role of logistics service providers.

Module 5: Global Logistics and Emerging Supply Chain Technologies (8 Hours)

Global supply chain operations – international logistics, trade documentation and customs procedures – reverse logistics and product return management – recycling remanufacturing and waste reduction practices – sustainable and green logistics – environmental considerations in logistics operations – digital supply chains and emerging technologies – Internet of Things in logistics, blockchain applications, artificial intelligence and data analytics for supply chain optimization.

Textbooks

1. Sunil Chopra and Peter Meindl, *Supply Chain Management: Strategy, Planning and Operation*, Pearson Education.
2. Martin Christopher, *Logistics and Supply Chain Management*, Pearson Education.

Reference Books

1. Coyle J., Langley C., Novack R. and Gibson B., *Supply Chain Management: A Logistics Perspective*, Cengage Learning.
2. Donald J. Bowersox, David J. Closs, and M. Bixby Cooper, *Supply Chain Logistics Management*, McGraw-Hill.
3. David Simchi-Levi, Philip Kaminsky, and Edith Simchi-Levi, *Designing and Managing the Supply Chain*: Concepts, Strategies and Case Studies, McGraw-Hill.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Evolution and scope of logistics and supply chain management – definition, importance, role in manufacturing and service sectors	2
1.2	Supply chain structure and flows – suppliers, manufacturers, distributors, retailers – material, information and financial flows	2
1.3	Logistics drivers – facilities, inventory, transportation and information – coordination in supply chains	2
1.4	Logistics performance measurement – customer service levels, logistics costs and key performance indicators	1
	Module 2	**7**
2.1	Demand planning and forecasting – qualitative and quantitative forecasting methods	2
2.2	Demand variability and bullwhip effect in supply chains	2
2.3	Inventory management concepts – types of inventory, inventory costs and service levels	2
2.4	Inventory control techniques – EOQ model, safety stock, reorder point, ABC classification	1
	Module 3	**7**
3.1	Warehouse operations and functions – receiving, storage, order picking and dispatch	2
3.2	Warehouse layout and material handling – storage systems, palletization, material handling equipment	2
3.3	Distribution center operations – order fulfillment, packaging and unitization	2
3.4	Warehouse automation and information systems – barcode, RFID, warehouse management systems	1
	Module 4	**7**
4.1	Transportation systems and modes – road, rail, air, sea and pipeline transportation	2
4.2	Freight transportation economics and carrier selection	2
4.3	Transportation planning – routing, scheduling and shipment consolidation	2
4.4	Logistics network design – facility location, distribution strategies	1

	and third party logistics services	
	Module 5	**8**
5.1	Global logistics and international supply chains – trade documentation and customs procedures	2
5.2	Reverse logistics – product returns, recycling, remanufacturing and waste reduction	2
5.3	Sustainable and green logistics – environmental considerations in supply chain operations	2
5.4	Digital supply chains – IoT, blockchain, artificial intelligence and data analytics in logistics	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1)

1. What are Key Performance Indicators (KPIs) in logistics?
2. Explain the role of logistics in manufacturing industries.
3. Explain the structure of a supply chain with a neat diagram and discuss the flow of materials, information and finances.
4. Discuss the major logistics drivers influencing supply chain performance. Explain how these drivers affect efficiency and responsiveness.

Course Outcome 2 (CO2)

1. Explain ABC inventory classification.
2. What is Vendor Managed Inventory (VMI)?
3. Explain various demand forecasting methods used in supply chain management.
4. A company has an annual demand of **10,000 units** for a product.
   - Ordering cost = ₹500 per order
   - Holding cost = ₹20 per unit per year

   Calculate:

   a) Economic Order Quantity (EOQ)
   b) Number of orders per year
   c) Total annual ordering cost.

Course Outcome 3 (CO3):

1. What is a Warehouse Management System (WMS)?
2. Explain the role of distribution centers.
3. Describe various material handling systems used in modern warehouses.
4. A warehouse stores 5,000 pallets of goods. Each pallet occupies 1.2 m² of storage space. Determine the minimum floor area required if 20% extra space is provided for aisles and

movement. Explain how warehouse layout influences operational efficiency.

Course Outcome 4 (CO4):

1. Define logistics network design.
2. What are the factors influencing transportation mode selection?
3. Explain different transportation modes and discuss their advantages and limitations in logistics operations.
4. Discuss the role of third-party logistics providers in supply chain management.

Course Outcome 5 (CO5)

1. What is blockchain in supply chain management?
2. Define supply chain resilience.
3. Explain reverse logistics and its importance in sustainable supply chains.
4. Discuss the role of digital technologies such as IoT, blockchain and artificial intelligence in modern logistics.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

EIGHTH SEMESTER B TECH DEGREE EXAMINATION, APRIL 2028

Course Code: **B24ME4P65**

Course Name: **LOGISTICS AND SUPPLY CHAIN MANAGEMENT**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What are the key logistics drivers in supply chain management?
2. List the key performance indicators (KPIs) used in logistics operations.
3. What is safety stock?
4. Explain ABC inventory classification.
5. What is palletization?
6. List different types of material handling equipment used in warehouses.
7. What is shipment consolidation?
8. What is third-party logistics (3PL)?
9. What is green logistics?
10. What is the role of IoT in logistics?.

PART B

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

Module 1

11. Discuss the major logistics drivers influencing supply chain performance. Explain how these drivers affect efficiency and responsiveness. (14 marks)

OR

12. A manufacturing company distributes products to three regional warehouses. The demand for the warehouses is 400, 600 and 800 units per week respectively. If the

transportation cost per unit from the plant to each warehouse is ₹12, ₹10 and ₹8 respectively:
Determine the total weekly transportation cost. Discuss how logistics decisions affect overall supply chain cost. (14marks)

Module 2

13. A company has an annual demand of 10,000 units for a product.

    Ordering cost = ₹500 per order
    Holding cost = ₹20 per unit per year

    Calculate:

    a) Economic Order Quantity (EOQ)
    b) Number of orders per year
    c) Total annual ordering cost. (14marks)

OR

14. The average daily demand of a product is 60 units and lead time is 5 days. Safety stock maintained is 100 units.

    Determine the Reorder Point (ROP).

    Explain the importance of safety stock in supply chains. (14marks)

Module 3

15. Describe various material handling systems used in modern warehouses. (14marks)

OR

16. A warehouse stores 5,000 pallets of goods. Each pallet occupies 1.2 m² of storage space. Determine the minimum floor area required if 20% extra space is provided for aisles and movement.
    Explain how warehouse layout influences operational efficiency. (14marks)

Module 4

17. Explain different transportation modes and discuss their advantages and limitations in logistics operations. (14marks)

OR

18. A logistics company must transport 2000 units of goods over 800 km.

    Available transport options:

    Road transport cost = ₹3 per unit per km
    Rail transport cost = ₹2 per unit per km

    Calculate:

    a) Total transportation cost for both modes
    b) Which mode is more economical?
    c) Discuss factors other than cost influencing transportation mode selection.

    (14marks)

Module 5

19. Discuss the role of digital technologies such as IoT, blockchain and artificial intelligence in modern logistics. (14 marks)

OR

20. A company ships 10,000 products annually internationally. The transportation cost per product is ₹150, customs duty is 10% of product value, and the product value is ₹1000 each.

    Calculate:

    a) Total annual transportation cost
    b) Total customs duty paid annually
    c) Total logistics cost related to these two factors. (14 marks)

B24ME4P66	BASICS OF PLC PROGRAMMING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

This course introduces mechanical engineering students to the fundamentals of control systems and their practical implementation in modern industrial automation. It begins with essential concepts such as open- and closed-loop control, system response, and controller actions, building a foundation for understanding dynamic system behavior. The course then transitions to programmable logic controllers (PLCs), covering hardware architecture and programming fundamentals widely used in manufacturing and process industries. Students develop hands-on understanding of ladder logic and structured text programming for both digital and analog control applications. Finally, the course explores contemporary automation technologies, including SCADA, DCS, Industrial Internet of Things (IIoT), and Industry 4.0 concepts, enabling learners to connect traditional mechanical systems with intelligent, data-driven automation solutions used in modern engineering practice.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the fundamentals of control systems, system response, and PID controllers. (Cognitive Knowledge Level: Understand)
CO 2	Explain PLC architecture, addressing, and scan cycle, and compare PLCs with conventional computing systems. (Cognitive Knowledge Level: Understand)
CO 3	Develop ladder logic programs using contacts, coils, timers, counters, and logical operations. (Cognitive Knowledge Level: Apply)
CO 4	Develop structured text (ST) programs using control statements, data types, timers, and counters. (Cognitive Knowledge Level: Apply)
CO 5	Explain the fundamentals and industrial relevance of SCADA, DCS, IIoT, and Industry 4.0. (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	-	-	-	-	-	-	-	1
CO 2	3	2	1	-	2	-	-	-	-	-	1
CO 3	3	3	3	1	3	-	-	-	1	1	1
CO 4	3	3	2	1	3	-	-	-	1	1	1
CO 5	3	2	1	-	2	-	1	-	-	1	1

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	40	10	10
Understand	60	30	30
Apply	-	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1 (8 hours): Fundamentals of Control Systems

Basics of Control Systems: Open-loop and closed-loop control, Block diagram representation, Effect of feedback, Significance of feedback control systems, practical examples. Transfer function approach (basic idea). Total response – Transient response and steady state response (first order systems), Time constant, Steady-state error. Types of Controllers: On-Off Control, Proportional (P) Control, Integral (I) Control, Derivative (D) Control, PI Controller, PD Controller, PID Controller.

MODULE 2 (5 hours): PLC Hardware and Programming Fundamentals

Introduction to PLC: Evolution, Advantages of PLC, Applications of PLC in industry. PLC Hardware Architecture: CPU, Memory, Input modules, Output modules, Power supply, Communication modules. PLC Addressing and Symbols: Input addresses, Output addresses, Internal relays, Coils, Contacts (NO/NC), Scan Cycles, Timer and counter symbols, Data registers. PLC Programming Languages (Overview): Ladder Diagram (LD), Function Block Diagram (FBD), Structured Text (ST), Instruction List (IL), Sequential Function Chart (SFC).

MODULE 3 (9 hours): Ladder Logic Programming for Digital and Analog Systems.

Basics of Ladder Logic: Power rails, Rungs, Output coils, Latching and unlatching circuits. Digital Logic Implementation: AND logic, OR logic, NOT logic, Interlocking circuits Timers: ON-delay timer, OFF-delay timer, Retentive timer. Counters: Up counter, Down counter, Up/Down counter, Reset function (Digital Systems).

Analog Signals in PLC: Difference between digital and analog signals, Analog input and output modules, Signal ranges (0–10 V, 4–20 mA), Signal conditioning. Scaling and Conversion: Analog-to-digital conversion, Scaling analog values in PLC, Basic analog signal processing and control applications.

MODULE 4 (7 hours): Structured Text (ST) Programming

Introduction to Structured Text, Syntax and Structure, Variables and Data Types, Logical and Arithmetic Operations, IF statement, CASE statement, FOR and WHILE loops, Timers and Counters in ST.

MODULE 5 (7 hours): Modern Automation

Introduction to SCADA: Meaning and need of SCADA, SCADA system architecture, Human Machine Interface (HMI), Distributed Control System (DCS): Basic concept of DCS, Comparison between SCADA and DCS, Modern Industrial Automation Concepts: Introduction to Industrial Internet of Things (IIoT), Cloud-based monitoring, Smart Factory concepts, Industry 4.0.

Text Books

1. W. Bolton, *Programmable Logic Controllers*, Newnes / Elsevier.
2. John W. Webb & Ronald A. Reis, *Programmable Logic Controllers: Principles and Applications,* Pearson.
3. M. T White, *Mastering PLC Programming*, Packt Publishing Ltd.
4. Frank D. Petruzella, *Programmable Logic Controllers*, McGraw Hill.

5. S.K. Saha, *Industrial Automation and Control*, McGraw Hill.

Reference Books

1. Katsuhiko Ogata, *Modern Control Engineering*, Pearson.
2. Josef Bernhardt, *PLC Programming with Raspberry Pi and OpenPLC Project*, Elektor International Media.
3. S.K. Singh, *Industrial Instrumentation and Control*, McGraw Hill.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	MODULE 1	**8**
1.1	Open-loop & Closed-loop systems – Block diagram – Effect of feedback – Significance of feedback control systems	2
1.2	Transfer function approach – Total response - transient and steady state response (first order)	2
1.3	Time Constant - Steady-state error	1
1.4	Types of Controllers: On-Off, P, I, D controllers	1
1.5	Types of Controllers: PI, PD, PID controllers – Industrial applications	2
	MODULE 2	**5**
2.1	Evolution of PLC – Advantages – Applications	1
2.2	PLC Hardware Architecture – CPU, Memory, Power supply, I/O modules	1
2.3	PLC Addressing – Internal relays – Coils – Contacts – Data registers	1
2.4	Scan cycle - Input scan, Program scan, Output scan	1
2.5	PLC Programming Languages – LD, FBD, ST, IL, SFC	1
	MODULE 3	**9**
3.1	Ladder basics – Power rails – Rungs – Latching & unlatching	1
3.2	Digital logic implementation – AND, OR, NOT – Interlocking circuits	1
3.3	Timers – ON-delay, OFF-delay, Retentive timers	1
3.4	Counters – Up, Down, Up/Down – Reset – Combined applications	2
3.5	Analog vs Digital signals – Analog I/O – Signal ranges (0–10V, 4–20mA)	2
3.6	Basic analog control using PLC	2
	MODULE 4	**7**
4.1	Introduction to ST, Syntax and Structure, Variables and Data Types	1
4.2	Variables and Data Types	1
4.3	Decision making and loops	1

4.4	Timers in ST	2
4.5	Counters in ST	2
	MODULE 5	**7**
5.1	SCADA – Architecture – HMI – Data acquisition	2
5.2	Distributed Control System (DCS)	2
5.3	IIoT, Cloud-based monitoring	2
5.4	Industry 4.0	1
	Total	**36 Hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Define open-loop and closed-loop control systems with suitable block diagrams
2. Explain the working principle of On-Off control with a practical example.
3. Explain the structure of a PID controller with a block diagram.

Course Outcome 2 (CO2):

1. Compare a PLC with a general-purpose computer
2. With the help of a block diagram explain structure of a PLC
3. Explain various type of programming used in PLC as per IEC 61131-3 standard

Course Outcome 3 (CO3):

1. Differentiate between digital and analog devices used in PLC systems.
2. Explain the various types of timers used in PLC with suitable examples.
3. With the help of a suitable ladder diagram, explain the function of an Up-Counter in PLC

Course Outcome 4 (CO4)

1. Write a Structured Text program to implement a simple motor start–stop control logic
2. Write an ST program to turn ON a lamp when temperature exceeds 60°C.
3. Write a Structured Text program to start a motor 5 seconds after a start push button is pressed

Course Outcome 5 (CO5)

1 Define SCADA and explain its basic architecture and applications.

2 Define IIoT and explain its significance in automation.

3 Discuss the advantages of Smart Factory implementation in modern manufacturing

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: **B24ME4P66**

Course Name: **BASICS OF PLC PROGRAMMING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 Define feedback and state its significance in control systems.

2 Define time constant and steady-state error.

3 Compare a PLC with a general-purpose computer.

4 List and explain the major components of a PLC.

5 Differentiate between ON-delay and OFF-delay timers.

6 Differentiate between digital and analog signals used in PLC systems.

7 Write a Structured Text program to start a motor when Start push button is pressed and stop it when Stop push button is pressed

8 Explain the use of IF–THEN–ELSE and CASE statements in Structured Text.

9 Explain cloud-based monitoring systems.

10 What is SCADA?

PART B

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

Module 1

11 Explain open-loop and closed-loop control systems with block diagrams and discuss the effect of feedback on system (14 marks)

OR

12 Derive the total response of a first-order system for a step input and explain transient and steady-state response. (14 marks)

Module 2

13 With a neat block diagram, explain the structure, internal architecture and operation of a PLC. (14 marks)

OR

14 Explain the addressing system of PLC and describe the different programming languages as per IEC 61131-3 standard. (14 marks)

Module 3

15 Develop a ladder logic program for an automatic water tank filling system with dry-run protection under the following conditions:

- The pump should start automatically when the water level in the overhead tank falls below the Low-level sensor.
- The pump should stop when the water reaches the High-level sensor.
- If the pump starts but water flow is not detected within 30 seconds (dry run condition), the pump must automatically stop.
- A dry-run alarm indicator should turn ON when this condition occurs.
- The system should include a manual RESET push button to clear the dry-run alarm.

Draw the ladder diagram and explain the sequence of operation (14 marks)

OR

16 Explain the operation and applications of timers and counters in PLC with suitable ladder diagrams. (14 marks)

Module 4

17 Develop a Structured Text program for a traffic signal system with the following sequence:

- Red (30 sec) → Green (25 sec) → Yellow (5 sec)
- The cycle should repeat continuously.
- Provide a manual STOP switch.

Write the ST program using timers and explain the sequence control. (14 marks)

OR

18 Develop an ST program for a parking system where:

- Entry sensor increments count.
- Exit sensor decrements count.
- Display available slots.
- Gate closes when parking is full.

Explain counter and logical operations used. (14 marks)

Module 5

19 Explain the basic concept of a Distributed Control System (DCS). Describe its architecture and discuss how it is used in large-scale industrial processes. (14 marks)

OR

20 Describe the concept of Industry 4.0. Explain its key principles and enabling technologies in modern manufacturing systems. (14 marks)

B24ME4G31	FACILITY LOCATION AND PLANNING	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Efficient facility location and planning are essential for organizations to achieve cost efficiency, operational effectiveness, and customer satisfaction. In a rapidly evolving industrial and service environment, decisions related to facility placement, layout, and capacity significantly impact productivity and competitiveness. This course introduces students from diverse engineering backgrounds to analytical and practical approaches for facility location and layout planning, integrating decision-making tools, real-world case studies, and emerging trends in digital and sustainable facility design.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the fundamentals of facility planning, types of facilities, and factors influencing location decisions. (Cognitive Knowledge Level: Understand)
CO 2	Apply quantitative techniques such as factor rating, center of gravity, and break-even analysis for facility location decisions. (Cognitive Knowledge Level: Apply)
CO 3	Apply systematic layout planning techniques to design efficient facility layouts. (Cognitive Knowledge Level: Apply)
CO 4	Apply capacity planning and material handling concepts in facility operations. (Cognitive Knowledge Level: Apply)
CO 5	Explain modern practices such as lean, sustainable, and digital facility planning. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	2	1									
CO 2	3	3	2		2						
CO 3	2	2	3		1			1			
CO 4	2	2	2		2			1		2	
CO 5	1	1	1		1	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	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Facility Planning Fundamentals (7 Hours)

Introduction to facility systems; role of facilities in manufacturing and service sectors; types of facilities (production, service, distribution); facility life cycle; factors influencing location decisions (cost, market, infrastructure, regulations, environment); decision-making framework; introduction to plant layout concepts; real-world examples.

Module 2: Location Decision Models (7 Hours)

Quantitative location models: factor rating method; break-even analysis; center of gravity method; load-distance method; introduction to transportation model for location decisions; qualitative considerations in site selection; use of spreadsheets/tools for location analysis; applications in logistics, retail, and service sectors.

Module 3: Plant Layout Design and Analysis (7 Hours)

Objectives and principles of layout design; types of layouts – product, process, cellular and hybrid layouts; flow patterns and process mapping; relationship diagrams and from-to charts; introduction to systematic layout planning (SLP); space planning; material handling considerations; layout performance measures; layout evaluation with examples.

Module 4: Capacity and Facility Operations Planning (7 Hours)

Capacity planning concepts; demand forecasting for capacity decisions; capacity strategies – lead, lag and match; bottleneck identification and management; basic line balancing concepts; facility operations planning; performance considerations in manufacturing and service facilities.

Module 5: Contemporary Practices in Facility Planning (8 Hours)

Lean facility layout and waste reduction; agile and flexible facilities; sustainable and green facility planning; digital facility planning tools – simulation and CAD-based layouts; smart factories and Industry 4.0 concepts; basics of warehouse and distribution center design; facility planning in emerging sectors such as healthcare, e-commerce and IT services; case studies.

Text Books

1. James A. Tompkins et al., *Facilities Planning*, Wiley.
2. D. R. Sule, *Manufacturing Facilities: Location, Planning and Design*, Cengage Learning.

Reference Books

1. Richard L. Francis et al., *Facility Layout and Location: An Analytical Approach*, Prentice Hall.
2. Krajewski, Ritzman, and Malhotra, *Operations Management*, Pearson.
3. S. K. Sharma and Savita Sharma, *Industrial Engineering and Operations Management*, S. K. Kataria & Sons.
4. Meyers and Stephens, *Manufacturing Facilities Design and Material Handling*, Pearson.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Introduction to facility planning and types of facilities	2
1.2	Factors influencing location decisions	2
1.3	Facility planning process and layout types	2
	Case discussion	1
	Module 2	**7**
2.1	Factor rating method	2
2.2	Center of gravity method	2
2.3	Break-even analysis	2
2.4	Applications and case study	1
	Module 3	**7**
3.1	Principles of layout design	2
3.2	Types of layouts and applications	2
3.3	SLP and relationship charts	2
3.4	Layout evaluation	1
	Module 4	**7**
4.1	Capacity planning concepts	2
4.2	Capacity strategies and bottlenecks	2
4.3	Material handling systems	2
4.4	Safety and ergonomics	1
	Module 5	**8**
5.1	Lean and flexible facility design	2
5.2	Sustainable facility planning	2
5.3	Digital tools and Industry 4.0	2
5.4	Case studies and course review	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1)

1. What is meant by facility life cycle.
2. List the different types of facilities in manufacturing and service sectors.
3. Explain factors influencing facility location with examples.
4. Discuss facility planning process and layout types.

Course Outcome 2 (CO2)

1. What is factor rating method?
2. What is the purpose of the load-distance method?

3. Solve a location problem using factor rating method (given data). *(Problem)*
4. Solve a center of gravity problem with coordinates and demand. *(Problem)*

Course Outcome 3 (CO3)

1. What is process mapping?
2. What is SLP?
3. Design a facility layout using SLP for given data. *(Problem)*
4. Analyze different layout types with examples.

Course Outcome 4 (CO4):

1. Define capacity planning.
2. What is lag capacity strategy?
3. What is meant by capacity utilization?
4. Explain the concept of line balancing and its role in improving facility operations.

Course Outcome 5 (CO5)

1. What is meant by a smart factory?
2. What is sustainable facility planning?
3. Explain lean facility layouts and discuss their role in waste reduction and operational efficiency.
4. Discuss digital tools in facility planning.

MODEL QUESTION PAPER

QP CODE: Pages: 3

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

SEVENTH SEMESTER B TECH DEGREE EXAMINATION, DECEMBER 2027

Course Code: **B24ME4G31**

Course Name: **FACILITY LOCATION AND PLANNING**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1 List the different types of facilities in manufacturing and service sectors?

2 What is facility life cycle?

3 What is break-even analysis?

4 List steps in location decision.

5 What is a relationship chart?

6 List types of layouts.

7 Define capacity planning in facility operations.

8 Explain the concept of line balancing.

9 What is Industry 4.0?

10 Define smart factory.

PART B

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

Module 1

11 A company plans to set up a new facility. The following factors influence the location decision:

- Raw material availability (High priority)
- Transportation cost (Medium priority)
- Labor availability (High priority)
- Environmental regulations (Medium priority)

Explain how these factors influence facility location and discuss a systematic approach to selecting a suitable location. (14 marks)

OR

12 Explain the concept of facility systems and discuss the role of facilities in manufacturing and service industries. (14 marks)

Module 2

13 Compare two facility locations using break-even analysis:

- Location A: Fixed cost = ₹1,00,000; Variable cost = ₹20/unit
- Location B: Fixed cost = ₹1,50,000; Variable cost = ₹15/unit

Find the break-even point and suggest the better location. (14 marks)

OR

14 Determine the optimal location of a warehouse:

Location	x	y	Demand
A	2	3	40
B	6	5	60
C	8	2	50

Find the coordinates of the facility location. (14 marks)

Module 3

15 Develop an activity relationship chart for the following departments:

- Stores (S)
- Assembly (A)
- Inspection (I)
- Dispatch (D)

Given closeness ratings:

- S–A: A (Absolutely necessary)
- A–I: E (Especially important)
- I–D: A
- S–D: U (Unimportant)

Construct the relationship diagram. (14 marks)

OR

16 A facility has the following material flow (units/day):

From/To	A	B	C	D
A	-	20	30	10
B	20	-	25	15
C	30	25	-	20
D	10	15	20	-

1. Prepare a from-to chart
2. Suggest an improved layout to minimize material handling (14 marks)

Module 4

17 A production line has the following processing times:

Machine	Time (min/unit)
M1	5
M2	8
M3	6
M4	10

1. Identify the bottleneck machine
2. Calculate system capacity (units/hour) (14 marks)

OR

18 A factory transports 500 kg loads over 50 m distance, 20 times/day.
Available options:

- Conveyor (₹2,00,000 initial cost, low operating cost)
- Forklift (₹5,00,000 initial cost, high flexibility)

Analyze and recommend a suitable system based on cost and usage. (14 marks)

Module 5

19 A warehouse is planning to implement Industry 4.0 tools such as IoT sensors and automation.
Explain how these technologies improve facility performance. (14 marks)

OR

20 A manufacturing firm wants to adopt lean facility design.

- Current waste: 20% material loss
- Lead time: 10 days

Explain how lean principles can improve efficiency. (14 marks)

B24ME4G32	TOTAL QUALITY MANAGEMENT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Quality is a key factor in achieving engineering excellence and customer satisfaction in today's competitive environment. This course introduces students to the fundamental concepts of Quality Management and Total Quality Management (TQM), including quality philosophies, strategic quality practices, human and organizational aspects, statistical process control, and quality improvement tools. The course also provides exposure to contemporary practices such as Lean, Six Sigma, sustainability, and digital transformation in quality management. It equips students with essential knowledge to apply quality principles in engineering design, operations, and continuous improvement initiatives.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the evolution of quality management, TQM principles, cost of quality, and contributions of quality gurus (Cognitive Knowledge Level: Understand).
CO 2	Describe strategic quality management concepts including VOC, QFD, benchmarking, Lean, 5S, Kaizen and Six Sigma (Cognitive Knowledge Level: Understand).
CO 3	Explain the human and organizational aspects of TQM including leadership, teamwork, ISO 9000 standards and quality culture (Cognitive Knowledge Level: Understand).
CO 4	Interpret statistical quality control tools such as control charts, process capability indices and reliability concepts (Cognitive Knowledge Level: Understand).
CO 5	Explain seven QC tools, FMEA, TPM, robust design, sustainability and digital transformation in quality management (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	–	1	–	1
CO 2	3	2	1	–	2	1	–	–	1	2	1
CO 3	2	–	–	–	–	1	2	3	2	1	1
CO 4	3	3	1	2	2	–	–	–	1	–	1
CO 5	2	2	2	1	3	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	40	40
Understand	60	60	60
Apply			
Analyse			
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

MODULE 1 – Quality Philosophy and Evolution (7 Hours)

Introduction to quality engineering concepts: definitions of quality, quality planning, quality control, quality assurance, quality management, evolution from inspection to TQM, TQM axioms and consequences of total quality- barriers to TQM implementation- cost of quality (prevention, appraisal, failure costs)- contributions of W. Edwards Deming including PDCA cycle, Joseph M. Juran including Quality Trilogy, Philip B. Crosby including fourteen steps for quality improvement.

MODULE 2 – Strategic and Customer-Centric Quality Management (7 Hours)

Strategic quality management, integration of quality into organizational strategy- customer satisfaction and Voice of Customer- Quality Function Deployment (QFD) concept, obstacles to strategic quality implementation, benchmarking basics- concepts of 5S, Kaizen, Lean thinking, introduction to Six Sigma and DMAIC framework (conceptual).

MODULE 3 – Human and Organizational Dimensions of TQM (7 Hours)

Human aspects of TQM- top management commitment, leadership for quality, change management, employee involvement, empowerment and motivation, teamwork and self-managed teams, training for quality, role of quality leadership- overview of ISO 9000 family of standards, documentation requirements and quality culture development.

MODULE 4 – Process Quality and Statistical Thinking (8 Hours)

Quality control and inspection concepts, common and special causes of variation, fundamentals of statistics for quality, control charts for $\bar{X}$ and R (interpretation only), process capability indices Cp and Cpk (conceptual), acceptance sampling (overview), reliability concepts, types and causes of failures, bath tub curve, quality auditing and corrective actions.

MODULE 5 – Quality Improvement Tools and Contemporary Practices (7 Hours)

Seven quality control tools: check sheets, Pareto chart, cause and effect diagram, histogram, scatter diagram and flow chart, affinity diagram and brainstorming- Failure Mode and Effect Analysis (FMEA) concept- Total Productive Maintenance (overview), robust design and Taguchi philosophy (conceptual)- sustainability and green quality initiatives- digital transformation in quality management.

Note: Each student may be assigned one case study from any one of the modules. The cases should be designed at or below Bloom's Level 3.

TEXT BOOKS

1. Dale H. Besterfield et al., *Total Quality Management*, Pearson Education.
2. K. K. Ramachandran & G. K. Suri, *Total Quality Management*, McGraw Hill Education.

REFERENCE BOOKS

1. James R. Evans & William M. Lindsay, *The Management and Control of Quality*, Cengage Learning.
2. S. Thomas Foster, *Managing Quality: Integrating the Supply Chain*, Pearson Education.
3. Poornima M. Charantimath, *Total Quality Management*, Pearson Education.
4. N. V. R. Naidu & K. M. Babu, *Total Quality Management*, New Age International.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Introduction to quality engineering, Definitions: quality, quality planning, QC, QA, QM; Evolution of quality, TQM philosophy, axioms and consequences.	2
1.2	Barriers to TQM implementation; Cost of Quality: prevention, appraisal, failure costs; Contributions of W. Edwards Deming; PDCA Cycle and 14 Points philosophy.	2
1.3	Contributions of Joseph M. Juran; Quality Trilogy concept; Contributions of Philip Crosby; 14 Steps for Quality Improvement	2
1.4	Comparative analysis of Deming, Juran and Crosby; Module discussion and short case.	1
	Module 2	**7**
2.1	Strategic quality management; Integrating quality with organizational strategy; Customer satisfaction and Voice of Customer (VOC); Customer-driven quality.	2
2.2	Quality Function Deployment (QFD) – concept and House of Quality; Obstacles to strategic quality implementation; Benchmarking fundamentals;5S principles; Kaizen philosophy.	3
2.3	Lean thinking principles; Waste identification; Introduction to Six Sigma; DMAIC framework (conceptual overview).	2
	Module 3	**7**
3.1	Human aspects of TQM; Role of top management commitment; Leadership for quality; Change management principles; Employee involvement and empowerment; Motivation theories.	3
3.2	Teamwork and self-managed teams; Training for quality; Quality leadership roles and responsibilities; Overview of ISO standards; ISO 9000 family – structure and purpose.	2
3.3	Documentation requirements; Developing quality culture.	2
	Module 4	**8**
4.1	Quality control vs inspection; Variation: common vs special causes; Fundamentals of statistics for quality; Mean, range, standard deviation (conceptual).	3
4.2	Control charts – $\bar{X}$ and R charts (interpretation); Process capability indices: Cp and Cpk (conceptual understanding); Acceptance sampling (overview); Reliability concepts.	3
4.3	Types and causes of failures; Bath tub curve; Quality auditing and corrective action process; Module review, numerical illustrations.	2
	Module 5	**7**
5.1	7 QC tools overview, Affinity diagram, Brainstorming techniques.	2
5.2	Failure Mode and Effect Analysis (FMEA) – concept.	1
5.3	Total Productive Maintenance (overview); Robust design and Taguchi philosophy (conceptual).	2
5.4	Sustainability and green quality; Digital transformation in quality management; Course wrap-up and revision.	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Define quality planning, quality control, and quality assurance.
2. Differentiate between prevention cost and failure cost with examples.
3. Discuss the evolution of quality from inspection to TQM. Explain the axioms and consequences of total quality with suitable examples.
4. Explain the contributions of W. Edwards Deming, Joseph M. Juran, and Philip B. Crosby to quality management. Compare their philosophies.

Course Outcome 2 (CO2):

1. What is Voice of Customer (VOC)? Why is it important?
2. List the principles of Lean thinking.
3. Explain how quality can be integrated into organizational strategy. Discuss obstacles to strategic quality implementation.
4. Describe the concept of Quality Function Deployment (QFD). Illustrate the structure of the House of Quality.

Course Outcome 3 (CO3):

1. What is employee empowerment in TQM?
2. State the importance of top management commitment in TQM.
3. Discuss the role of leadership and change management in successful TQM implementation.
4. Explain the importance of teamwork, training, and employee involvement in building a quality culture.

Course Outcome 4 (CO4):

1. Distinguish between common causes and special causes of variation.
2. Define process capability indices Cp and Cpk.
3. Explain $\bar{X}$ and R control charts. Describe their construction and interpretation.
4. Discuss acceptance sampling and its role in quality control. Compare inspection and statistical quality control.

Course Outcome 5 (CO5)

1. What is a Pareto chart? State its significance.
2. List any four of the seven quality control tools.
3. Explain the seven quality control tools with suitable examples.
4. Describe the procedure for conducting FMEA. How does it help in risk reduction?

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: **B24ME4G32**

Course Name: **TOTAL QUALITY MANAGEMENT**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Differentiate between prevention cost and failure cost with examples.
2. State the key elements of the Quality Trilogy proposed by Joseph M. Juran.
3. List the principles of Lean thinking.
4. What are the phases of DMAIC in Six Sigma?
5. State the importance of top management commitment in TQM.
6. What is the purpose of the ISO 9000 family of standards issued by the International Organization for Standardization?
7. Define process capability indices Cp and Cpk.
8. Sketch and explain the bath tub curve.
9. List any four of the seven quality control tools.
10. Define Failure Mode and Effect Analysis (FMEA).

PART B

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

Module 1

11. Explain the contributions of W. Edwards Deming, Joseph M. Juran, and Philip B. Crosby to quality management. Compare their philosophies. (14 marks)

OR

12. Explain the concept of Cost of Quality. Discuss how proper quality planning reduces total quality cost in an organization. (14marks)

Module 2

13. Explain the concepts of 5S, Kaizen, Lean thinking, and Six Sigma. How do they support continuous improvement? (14marks)

OR

14. Describe the concept of Quality Function Deployment (QFD). Illustrate the structure of the House of Quality. (14marks)

Module 3

15. Explain the importance of teamwork, training, and employee involvement in building a quality culture. (14marks)

OR

16. Describe the structure of ISO 9000 standards and documentation requirements. How do they support quality assurance? (14marks)

Module 4

17. Discuss acceptance sampling and its role in quality control. Compare inspection and statistical quality control. (14marks)

OR

18. Explain reliability concepts, types of failures, and quality auditing procedures in manufacturing systems. (14marks)

Module 5

19. Describe the procedure for conducting FMEA. How does it help in risk reduction? (14 marks)

OR

20. Discuss Total Productive Maintenance, Taguchi philosophy, sustainability initiatives, and digital transformation in quality management.? (14 marks)

B24ME4G33	INTRODUCTION TO INDUSTRY 4.0	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Industry 4.0 represents the transformation of traditional industries through the integration of digital technologies such as automation, data analytics, artificial intelligence, robotics, and connected systems. Modern industrial environments increasingly rely on smart manufacturing and data-driven decision-making to improve productivity, efficiency, and sustainability. This course introduces students to the basic concepts of Industry 4.0, including smart manufacturing systems, industrial automation, data technologies, and emerging digital tools used in modern industries. The course emphasizes practical industrial applications and current technological trends to help students understand how Industry 4.0 technologies are transforming industrial operations.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the evolution of industrial revolutions and the fundamental concepts and enabling technologies of Industry 4.0. (Cognitive Knowledge Level: Understand)
CO 2	Describe the role of sensors, connected devices, and basic industrial communication systems in modern digital manufacturing environments. (Cognitive Knowledge Level: Understand)
CO 3	Explain the application of automation systems, PLC/SCADA, and machine communication in smart factories and industrial monitoring. (Cognitive Knowledge Level: Understand)
CO 4	Interpret the importance of industrial data, artificial intelligence, and cloud technologies in improving operational efficiency and decision-making. (Cognitive Knowledge Level: Understand)
CO 5	Identify major applications, emerging technologies, and future trends of Industry 4.0 including robotics, additive manufacturing, smart logistics, and sustainable production. (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	–	–	–	–	–	–	–	–	1
CO 2	3	2	–	–	2	–	–	–	–	–	1
CO 3	2	2	2	–	2	–	–	–	–	1	1
CO 4	2	2	–	1	2	–	–	–	–	–	1
CO 5	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	40	40	30
Understand	60	60	50
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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Introduction to Industry 4.0 (7 Hours)

Evolution of industrial revolutions – Industry 1.0, 2.0, 3.0 and 4.0 – concept of digital transformation in manufacturing – key enabling technologies: automation, robotics, cyber-physical systems, data analytics, artificial intelligence and connected devices – concept of smart factories and intelligent production systems – applications in manufacturing and service industries – benefits, opportunities and implementation challenges of Industry 4.0.

Module 2: Sensors and Connected Systems in Industry (7 Hours)

Role of sensors and data acquisition in modern industries – commonly used industrial sensors (temperature, pressure, vibration, proximity) – basic architecture of connected industrial systems – introduction to microcontrollers and embedded platforms – overview of industrial communication methods (Wi-Fi, Bluetooth, Ethernet) – concept of edge computing and cloud-based data storage – examples of connected industrial systems.

Module 3: Automation and Smart Manufacturing Systems (7 Hours)

Industrial automation concepts – introduction to programmable logic controllers (PLC) and supervisory control and data acquisition (SCADA) systems – machine-to-machine communication in automated systems – monitoring and control of machines in manufacturing – predictive maintenance concepts and industrial monitoring – digital twin concept and its role in smart manufacturing environments.

Module 4: Data Analytics, Artificial Intelligence and Cloud Technologies (7 Hours)

Importance of industrial data in modern factories – basics of data acquisition, visualization and dashboards – introduction to artificial intelligence and machine learning concepts (non-mathematical overview) – applications in industrial fault detection, quality monitoring and process optimization – overview of cloud computing platforms and industrial data storage – basic cybersecurity principles for connected industrial systems.

Module 5: Applications, Trends and Future Technologies (8 Hours)

Industrial robotics and collaborative robots (cobots) – introduction to additive manufacturing (3D printing) and its role in digital manufacturing – smart logistics and warehouse automation using AGVs and automated systems – energy-efficient and sustainable manufacturing – concept of Industry 5.0 and human–machine collaboration – national initiatives supporting digital manufacturing such as Make in India and Digital India – industrial case studies: Bosch Industry 4.0 implementations, Siemens Amberg Electronics Plant, Reliance Jio IoT platform.

Textbooks

1. Vikram Bansal and Deepthi B., *Industry 4.0: A Sustainable Industrial Approach*, Sultan Chand & Sons, 2025.
2. Sudip Misra, Chandana Roy and Anandarup Mukherjee, *Introduction to Industrial Internet of Things and Industry 4.0*, CRC Press / Taylor & Francis, 2021.
3. Kaushik Kumar, Divya Zindani and J. Paulo Davim, Industry 4.0: *Developments Towards the Fourth Industrial Revolution*, Springer, 2019.

Reference Books

1. Ashish Bhanabhai Patel, *Industrial Revolution 4.0: Concepts, Technologies and Applications*, Shashwat Publication.
2. Ravi Kant and Hema Gurung, *Industry 4.0: Concepts, Processes and Systems*, CRC Press, 2024.
3. Ketan Kotecha, Satish Kumar, Arunkumar Bongale and R. Suresh*, Industry 4.0 in Small and Medium-Sized Enterprises (SMEs),* CRC Press, 2022.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Evolution of Industrial Revolutions – Industry 1.0, 2.0, 3.0 and 4.0 – concept of digital transformation in manufacturing	2
1.2	Key enabling technologies – automation, robotics, cyber-physical systems, data analytics, artificial intelligence and connected devices	2
1.3	Smart factories and intelligent production systems – applications of Industry 4.0 in manufacturing and service industries	2
1.4	Benefits, opportunities and implementation challenges of Industry 4.0	1
	Module 2	**7**
2.1	Role of sensors and data acquisition – industrial sensors (temperature, pressure, vibration, proximity)	2
2.2	Architecture of connected industrial systems – introduction to microcontrollers and embedded platforms	2
2.3	Industrial communication methods – Wi-Fi, Bluetooth, Ethernet – concept of edge computing	2
2.4	Cloud-based data storage – examples of connected industrial systems	1
	Module 3	**7**
3.1	Industrial automation concepts – introduction to PLC systems	2
3.2	SCADA systems – machine-to-machine communication in automated systems	2
3.3	Monitoring and control of machines – predictive maintenance and industrial monitoring	2
3.4	Digital twin concept and role in smart manufacturing	1
	Module 4	**7**
4.1	Importance of industrial data – basics of data acquisition and management	2
4.2	Data visualization and dashboards – introduction to AI and machine learning concepts	2
4.3	Applications of AI in fault detection, quality monitoring and	2

	process optimization	
4.4	Cloud computing platforms – industrial data storage and cybersecurity basics	1
	Module 5	**8**
5.1	Industrial robotics and collaborative robots (cobots)	2
5.2	Additive manufacturing (3D printing) and smart logistics using AGVs	2
5.3	Energy-efficient and sustainable manufacturing – Industry 5.0 and human–machine collaboration	2
5.4	National initiatives (Make in India, Digital India) – industrial case studies: Bosch, Siemens Amberg Plant, Reliance Jio IoT	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1)

1. Define Industry 4.0. How is it different from Industry 3.0?
2. List the major industrial revolutions and mention one key feature of each.
3. Explain the evolution of industrial revolutions from Industry 1.0 to Industry 4.0 with suitable examples.
4. Discuss the key enabling technologies of Industry 4.0 such as automation, robotics, artificial intelligence and data analytics.

Course Outcome 2 (CO2)

1. What is the role of sensors in modern industrial systems?
2. List any four commonly used industrial sensors.
3. Explain the role of sensors and data acquisition systems in industrial monitoring with examples.
4. Describe the architecture of connected industrial systems including microcontrollers and embedded platforms.

Course Outcome 3 (CO3)

1. What is industrial automation?
2. Define PLC and mention its importance in industrial control.
3. Explain the concepts of industrial automation and discuss the working and applications of PLC systems.
4. Describe the structure and functions of SCADA systems used in industrial monitoring and control.

Course Outcome 4 (CO4)

1. Why is industrial data important in modern manufacturing systems?
2. What is data visualization? Give two examples.
3. Explain the importance of industrial data analytics and data visualization in modern factories.
4. Discuss the basic concepts of artificial intelligence and machine learning and their applications in industrial systems.

Course Outcome 5 (CO5)

1. What are collaborative robots (cobots)?
2. What is additive manufacturing?
3. Explain the role of industrial robotics and collaborative robots in modern manufacturing systems.
4. Discuss additive manufacturing and smart logistics technologies used in Industry 4.0 environments.

MODEL QUESTION PAPER

QP CODE: Pages: 2

Reg. No.: .....

Name : .....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

EIGHT SEMESTER B TECH DEGREE EXAMINATION, APRIL 2028

Course Code: **B24ME4G33**

Course Name: **INTRODUCTION TO INDUSTRY 4.0**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What is meant by a smart factory?
2. State two benefits and two challenges in implementing Industry 4.0.
3. What is meant by data acquisition in industrial systems?
4. What are microcontrollers? Mention their role in connected systems.
5. What is SCADA?
6. What is machine-to-machine (M2M) communication?
7. What is cloud computing?
8. What is cybersecurity in connected industrial systems?
9. What are Automated Guided Vehicles (AGVs)?
10. What is meant by sustainable manufacturing?

PART B

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

Module 1

11. Discuss the key enabling technologies of Industry 4.0 such as automation, robotics, artificial intelligence and data analytics. (14 marks)

OR

12. Explain the concept of smart factories and intelligent production systems and discuss their applications in manufacturing and service industries. (14 marks)

Module 2

13. Describe the architecture of connected industrial systems including microcontrollers and embedded platforms. (14 marks)

OR

14. Discuss industrial communication methods such as Wi-Fi, Bluetooth and Ethernet and their applications in connected industries. (14 marks)

Module 3

15. Describe the structure and functions of SCADA systems used in industrial monitoring and control. (14 marks)

OR

16. Explain predictive maintenance and digital twin concepts and discuss their role in smart manufacturing. (14 marks)

Module 4

17. Discuss the basic concepts of artificial intelligence and machine learning and their applications in industrial systems. (14 marks)

OR

18. Explain cloud computing platforms used in industries and discuss the importance of cybersecurity in connected systems. (14 marks)

Module 5

19. Discuss additive manufacturing and smart logistics technologies used in Industry 4.0 environments. (14 marks)

OR

20. Explain the concept of Industry 5.0 and discuss national initiatives such as Make in India and Digital India supporting digital manufacturing. (14 marks)

B24ME4G34	MAINTENANCE ENGINEERING AND MANAGEMENT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Maintenance Engineering and Management is an essential area that focuses on ensuring the reliable, safe, and efficient operation of equipment and systems in industrial and service organizations. This course introduces students to the fundamental concepts of maintenance strategies, reliability, condition monitoring, and maintenance planning. It also covers modern approaches such as Total Productive Maintenance (TPM), Reliability Centered Maintenance (RCM), safety practices, and maintenance management tools. The course aims to provide students with a basic understanding of how effective maintenance contributes to improved system performance, reduced downtime, and cost-efficient operations in multidisciplinary engineering environments.

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the objectives, functions, and types of maintenance systems and their role in improving equipment availability, cost efficiency, and operational safety. (Cognitive Knowledge Level: Understand)
CO 2	Describe basic reliability concepts and condition monitoring techniques used for fault detection and condition-based maintenance in engineering systems. (Cognitive Knowledge Level: Understand)
CO 3	Apply preventive maintenance principles to develop basic maintenance plans, schedules, and spare parts management strategies using inventory control methods and CMMS concepts. (Cognitive Knowledge Level: Apply)
CO 4	Apply the bathtub curve and Weibull distribution concepts to interpret equipment failure patterns, estimate component life, and evaluate system effectiveness. (Cognitive Knowledge Level: Apply)
CO 5	Explain modern maintenance strategies such as Total Productive Maintenance (TPM), Reliability Centered Maintenance (RCM), and safety practices along with basic maintenance cost concepts. (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	–	–	–	–	1
CO 2	3	2	–	1	2	–	–	–	–	–	1
CO 3	2	2	2	–	2	–	–	–	–	3	1
CO 4	3	3	–	2	1	–	–	–	–	–	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	30	30
Understand	60	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/ Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Introduction to Maintenance Management and Systems (6 hours)

Definitions and scope of maintenance engineering; objectives of maintenance – maximizing availability, minimizing downtime, reducing cost, and improving safety; types of maintenance – breakdown (corrective), preventive (time-based and usage-based), predictive/condition-based maintenance; overview of reliability-centered maintenance (RCM) and total productive maintenance (TPM); role of maintenance in manufacturing and service industries.

Module 2: Reliability Concepts and Condition Monitoring (7 hours)

Basic concept of reliability – definition, reliability function, failure rate, mean time between failures (MTBF), and their significance in maintenance decisions; introduction to condition-based maintenance and condition monitoring systems; basic monitoring methods – visual inspection, tactile and aural monitoring, leakage detection; temperature monitoring using thermography; thickness monitoring using ultrasonic methods; advantages and applications of condition monitoring.

Module 3: Maintenance Planning, Scheduling, and Management Tools (8 hours)

Principles of planned maintenance; development of preventive maintenance programs; maintenance scheduling using Gantt charts and priority systems; spare parts management and inventory control – objectives, ABC analysis, VED analysis, two-bin systems, safety stock concepts; estimation of spare requirements; computerized maintenance management systems (CMMS) – benefits, plant registers, maintenance records and reports; overview of maintenance management software.

MODULE 4: Failure Patterns and Reliability Analysis (7 hours)

Failure patterns and the bath-tub curve – early failure period, constant failure period and wear-out failure period; introduction to Weibull distribution – shape and scale parameters and graphical interpretation; use of Weibull analysis in describing component life; factors affecting reliability; reliability, availability and utilization factors; system effectiveness; introduction to reliability growth concepts.

Module 5: Modern Maintenance Strategies and Safety (8 hours)

Total Productive Maintenance (TPM) – goals, methodology and the eight pillars; Overall Equipment Effectiveness (OEE) and its calculation; 5S principles; Reliability Centered Maintenance (RCM) – principles, benefits and decision logic; safety practices in maintenance – safety engineering principles, lock-out/tag-out procedures, guidelines for safe maintenance work; maintenance costing and life cycle costing; maintenance budgeting and audits; overview of advanced condition monitoring technologies such as vibration monitoring, thermography and oil analysis.

Textbooks

1. A K Gupta & K C Khanna, *Maintenance Engineering and Management*, S. Chand.
2. S K Srivastava, *Industrial Maintenance Management*, S. Chand.
3. Charles E. Ebeling, *An Introduction to Reliability and Maintainability Engineering*, McGraw-Hill.

References

1. R. Keith Mobley, *Maintenance Engineering Handbook*, McGraw-Hill
2. John Moubray, *Reliability-Centered Maintenance (RCM)*, Industrial Press
3. D. J. Smith, *Reliability, Maintainability and Risk*, Butterworth-Heinemann

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**6**
1.1	Introduction, scope, objectives of maintenance – availability cost, safety	2
1.2	Breakdown, preventive (time/usage-based) maintenance	2
1.3	Predictive, RCM, TPM – introduction & comparison	2
	Module 2	**7**
2.1	Condition-based maintenance and condition monitoring – monitoring systems.	1
2.2	Basic concept of reliability – definition, reliability function, failure rate, mean time between failures (MTBF), and their significance in maintenance	2
2.3	Performance monitoring – visual, tactile and aural monitoring, leakage monitoring.	1
2.4	Temperature monitoring – thermography, advantages.	1
2.5	Thickness monitoring – acoustic monitoring.	1
2.6	Smell/odour monitoring.	1
	Module 3	**8**
3.1	Principles of planning & scheduling, PM program design	2
3.2	Inventory & spare parts management – ABC, VED, two-bin, safety stock	2
3.3	CMMS – functions, reports, software overview	2
3.4	Spare requirement calculations, plant registers, documentation	2
	Module 4	**7**
4.1	Failure patterns, bathtub curve	2
4.2	Weibull distribution – shape, scale, parameters	2
4.3	Weibull probability plot – interpretation & examples	2
4.4	System effectiveness, utilization factor, reliability growth	1
	Module 5	**8**
5.1	TPM – goals, pillars, 5S, OEE calculation	2
5.2	RCM – principles, steps, decision diagrams	2
5.3	Safety engineering, LOTO, risk assessment	2
5.4	Costing, LCC, budgeting, maintenance audits, condition monitoring	2
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. List any three objectives of maintenance.
2. Differentiate between breakdown and preventive maintenance.
3. Discuss the objectives, functions, and significance of maintenance management in modern industries.
4. Outline consumer buying behaviour using any consumer decision-making model. Illustrate how organizations use these insights for strategy.

Course Outcome 2 (CO2):

1. Define condition-based maintenance and explain its importance in maintenance management.
2. What is reliability? Explain the terms failure rate and mean time between failures (MTBF).
3. Describe the basic concepts of reliability, including reliability function, failure rate, and mean time between failures (MTBF). How do these concepts help in planning maintenance activities?
4. What are the different methods of condition monitoring for temperature, thickness, acoustic signals, and smell/odour? Mention at least one advantage of each method.

Course Outcome 3 (CO3):

1. Define CMMS and mention two of its benefits.
2. Write short notes on two-bin system.
3. Explain the process of maintenance planning and scheduling. Develop a PM schedule for any mechanical equipment.
4. Discuss ABC, VED, and two-bin systems. Prepare a spare parts classification for a sample inventory of 10 items.

Course Outcome 4 (CO4):

1. What is the bathtub curve?
2. Define shape and scale parameters in Weibull distribution.
3. Explain the bathtub curve in detail. Describe each of its three phases with industrial relevance.
4. Fit a Weibull distribution to given failure data (create any sample data). Explain parameter estimation and probability plotting.

Course Outcome 5 (CO5)

1. What is Lock-out/Tag-out (LOTO)?
2. Explain TPM and its eight pillars. Calculate OEE for a machine with assumed data and interpret results.
3. Describe the complete RCM process with decision diagrams. Explain how RCM improves reliability and safety.

MODEL QUESTION PAPER

QP CODE: Pages: 2

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

EIGHTH SEMESTER B TECH DEGREE EXAMINATION, APRIL 2028

Course Code: **B24ME4G34**

Course Name: **MAINTENANCE ENGINEERING AND MANAGEMENT**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Explain the objectives of maintenance and how they help improve equipment availability in industries.
2. Differentiate between preventive maintenance and predictive maintenance with suitable industrial examples.
3. List and briefly describe three performance monitoring techniques used in condition monitoring.
4. What is thermography in temperature monitoring? Explain.
5. What are the steps involved in preparing a preventive maintenance (PM) schedule?
6. Explain ABC analysis and how it helps in spare parts inventory management.
7. Describe the three regions of the bathtub curve and their industrial relevance.
8. Define the shape (β) and scale (η) parameters of the Weibull distribution and explain their significance in failure modelling.
9. What is Overall Equipment Effectiveness (OEE)? Mention its three components.
10. Explain the purpose of Lock-out/Tag-out (LOTO) procedures in maintenance activities.

PART B

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

Module 1

11. Discuss the different types of maintenance: breakdown, preventive, predictive, reliability centered maintenance, and TPM. Explain their advantages, limitations, and suitability for mechanical equipment with relevant examples. (14 marks)

OR

12. Explain the objectives and functions of maintenance management in modern industries. Illustrate how effective maintenance policies improve equipment availability, productivity, and safety. Provide mechanical engineering–related applications. (14 marks)

Module 2

13. Explain the concept of condition-based maintenance and its significance in industrial maintenance management. Include examples of monitoring systems used. (14 marks)

OR

14. List and explain various performance monitoring techniques such as visual, tactile, aural, and leakage monitoring used in condition monitoring. (14 marks)

Module 3

15. Explain the complete procedure for preparing a Preventive Maintenance (PM) program for a machining workshop. Include planning steps, scheduling tools (Gantt, priority systems), manpower allocation, documentation, and feedback mechanisms. (14 marks)

OR

16. What is a CMMS? Describe its architecture, functions, reports, and practical benefits in maintenance management. Explain how CMMS integrates with spare management, failure data, and maintenance scheduling using examples. (14 marks)

Module 4

17. Explain the bathtub curve and describe the characteristics of the early-failure, constant-failure, and wear-out periods. Using suitable examples, discuss how maintenance strategies differ for each region. (14 marks)

OR

18. A dataset of failure times for a ball-bearing shows Weibull parameters $\beta = 1.8$ and $\eta = 1800$ hours.
    a. Interpret the meaning of β and η.
    b. Compute reliability at 1000 hours and 2000 hours.
    c. Explain how Weibull probability plots help identify failure behaviour.
    d. Discuss how Weibull modelling supports preventive maintenance planning. (14 marks)

Module 5

19. Explain the pillars of Total Productive Maintenance (TPM) and discuss how TPM improves Overall Equipment Effectiveness (OEE). Using a hypothetical machine dataset, show how OEE is calculated and interpreted. (14 marks)

OR

20. Describe the complete Reliability-Centered Maintenance (RCM) process including system selection, functional failure analysis, FMEA, decision logic, task selection, and implementation. Explain how RCM improves reliability and cost-effectiveness with mechanical engineering examples. (14 marks)

B24ME4G35	NANOTECHNOLOGY AND APPLICATIONS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

Nanotechnology is a multidisciplinary field that involves manipulating matter at the atomic and molecular scale to create materials and devices with fundamentally new properties. This course provides a comprehensive introduction to nanostructures, their unique physical behaviors, and the specialized techniques required to fabricate and characterize them. Engineering students will explore the diverse applications of nanotechnology—ranging from high-performance materials and electronics to nanomachines and nanofluids—while understanding the technological shift from macro-scale to nano-scale engineering

Prerequisites

Nil

Course Outcomes

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

CO 1	Explain the classification of nanostructures and the effect of nanoscale dimensions on the fundamental properties of materials. (Cognitive Knowledge Level: Understand)
CO 2	Compare various "Top-down" and "Bottom-up" fabrication methods used in the synthesis of nanomaterials. (Cognitive Knowledge Level: Understand)
CO 3	Identify and describe the microscopy and spectroscopy techniques used for the characterization of nanostructures. (Cognitive Knowledge Level: Understand)
CO 4	Relate the applications of carbon nanotubes, nanosensors, and nanocomposites to modern engineering solutions. (Cognitive Knowledge Level: Apply)
CO 5	Discuss the principles of nanomachines, nanofluids, and molecular devices and their future impact on technology. (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	1	2	1	1	2	1	2	2
CO 2	3	3	2	3	2	1	2	2	1	2	3
CO 3	3	2	1	2	2	1	2	2	1	3	2
CO 4	3	3	2	2	3	1	1	2	2	3	3
CO 5	2	1	1	1	2	3	3	3	2	3	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 : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module) of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Introduction and Scope of Nanotechnology (7 Hours)

Introduction and scope of nanotechnology. Classification of nanostructures: Quantum dots, quantum wires, quantum wells, nanoclusters, nanotubes, superlattices, and nanocrystalline materials. Effects of nanometer length scale: Changes to the system total energy and changes to the system structures.

Module 2: Properties at the Nanoscale (7 Hours)

Effect of Nanoscale dimensions on various material properties: Structural, thermal, and chemical properties. Changes in mechanical, magnetic, optical, and electronic properties due to size confinement and surface-to-volume ratio.

Module 3: Fabrication Methods (8 Hours)

Top-down and Bottom-up approaches. Top-down processes: Milling, Lithographics, machining process, and pulsed laser methods. Bottom-up processes: Vapour phase deposition methods (PVD, CVD), electrodeposition, plasma-assisted deposition (MBE), chemical methods, and colloidal/sol-gel methods

Module 4: Characterization Techniques (7 Hours)

General classification of characterization methods. Microscopy techniques: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Tunneling Microscopy (STM), and Atomic Force Microscopy (AFM). Diffraction and Spectroscopy: Raman Spectroscopy, Surface analysis, and depth profiling. Measurement of mechanical, magnetic, and thermal properties at the nanoscale.

Module 5: Nano-Applications and Machines (7 Hours)

Applications: Nanocomposites, nanocrystalline materials, nano-layered structures, and nanomagnetic materials (magnetoresistance). Carbon nanotubes (SWNT, MWNT) and nanostructured coatings. Nanosensors: Electrochemical sensors, quantum size effect sensors, nanobiosensors, and smart dust. Nanomachines: Covalent and non-covalent approaches, molecular motors, and molecular devices. Nanofluids: Preparation and thermophysical properties. Introduction to nanoswitches, nanocomputers, and nanofilters

Textbooks

1. A.K. Bandyopdhyay, *Nanomaterials*, New Age International Publishers.
2. Charles P. Poole & Frank J. Owens, *Introduction to Nanotechnology*, John Wiley and Sons.

References

1. Bharat Bhushan, *Springer Handbook of Nanotechnology*.
2. T. Pradeep, *Nano: The Essentials,* McGraw-Hill Education.
3. Kelsall Robert W., Ian Hamley, & Mark Geoghegan, *Nanoscale Science and Technology,* Wiley Eastern.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**7**
1.1	Classification of nanostructures: Quantum dots, wires, wells	2
1.2	Nanoclusters, nanotubes, super lattices, nanocrystalline materials	2
1.3	Effects of nanometer length scale on system energy and structures	3
	Module 2	**7**
2.1	Fundamental Effects: Changes to system total energy and system structures due to nanometer length scale.	2
2.2	Primary Properties: Structural, thermal, and chemical properties at the nanoscale.	2
2.3	Functional Properties: Mechanical, magnetic, optical, and electronic properties; effect of size confinement.	2
2.4	Forecasting techniques, horizon scanning, emerging tech	1
	Module 3	**8**
3.1	Top-down: Milling, Lithographics, machining, pulsed laser methods	3
3.2	Bottom-up: PVD, CVD, electro deposition, plasma assisted deposition	3
3.3	Bottom-up: MBE, chemical methods, colloidal and sol-gel methods	2
	Module 4	**7**
4.1	Microscopy: SEM, TEM, STM, AFM	3
4.2	Diffraction and Spectroscopy: Raman Spectroscopy, Surface analysis	2
4.3	Measuring mechanical, magnetic, and thermal properties	2
	Module 5	**7**
5.1	Applications: Nanocomposites, nanostructured coatings, CNTs	2
5.2	Nanosensors: Electrochemical, quantum size effect, nanobiosensors	2
5.3	Nanomachines: Molecular motors, covalent/non-covalent approaches	2
5.4	Nanofluids: Preparation and thermophysical properties; Nanoswitches	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Define nanotechnology and explain the classification of nanostructures.
2. Discuss how the nanometer length scale changes the total energy of a system.
3. Explain the properties of quantum dots and quantum wires

Course Outcome 2 (CO2):

1. Compare top-down and bottom-up approaches in nanofabrication.
2. Describe the sol-gel method for synthesizing nanomaterials.
3. Explain the process of Chemical Vapour Deposition (CVD)

Course Outcome 3 (CO3):

1. Explain the working principle of Scanning Electron Microscopy (SEM).
2. Differentiate between STM and AFM in surface characterization.
3. Discuss the significance of Raman Spectroscopy in nano-analysis.

Course Outcome 4 (CO4):

1. Describe the structure and applications of Carbon Nanotubes (SWNT/MWNT).
2. Explain how nanobiosensors function and their industrial relevance.
3. Discuss the role of nanostructured coatings in improving mechanical properties.

Course Outcome 5 (CO5)

1. Define nanofluids and compare their thermophysical properties with base fluids.
2. Explain the concept of molecular motors and machines.
3. Describe the practical problems associated with molecular devices.

MODEL QUESTION PAPER

QP CODE: Pages: 2

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)
KOTHAMANGALAM

EIGHTH SEMESTER B TECH DEGREE EXAMINATION, APRIL 2028

Course Code: **B24ME4G35**

Course Name: **NANOTECHNOLOGY AND APPLICATIONS**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. Classify nanostructures based on their dimensions.
2. List three effects of the nanoscale on system structures.
3. Differentiate between magnetic and electronic properties at the nanoscale.
4. What is the basic principle of the pulsed laser method?
5. Briefly explain the PVD process.
6. Mention the primary use of Atomic Force Microscopy (AFM).
7. What is surface depth profiling in spectroscopy?
8. Define Magneto-resistance in nanomaterials.
9. What are molecular motors?
10. Define "Smart Dust" in the context of nanosensors.

PART B

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

Module 1

11. Explain in detail the classification of nanostructures including quantum dots, wires, and wells. (14 marks)

OR

12. Discuss how reducing dimensions to the nanometer scale affects the total energy and structural stability of a system. (14 marks)

Module 2

13. Analyze the effect of nanoscale dimensions on the mechanical and optical properties of materials. (14 marks)

OR

14. Explain how thermal and chemical properties change when a material is transitioned to a nanocrystalline state. (14 marks)

Module 3

15. Compare the Top-down and Bottom-up fabrication approaches. Detail the milling and lithographic processes. (14 marks)

OR

16. Describe the Sol-gel and Vapour phase deposition methods for nanoparticle synthesis. (14 marks)

Module 4

17. Explain the principle and working of Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM). (14 marks)

OR

18. Discuss Raman Spectroscopy and Diffraction techniques used in characterizing nanomaterials. (14 marks)

Module 5

19. Discuss the preparation of nanofluids and compare their thermophysical properties with those of traditional base fluids. (14 marks)

OR

20. Explain the applications of Carbon Nanotubes and the various types of nanosensors used in modern industry. (14 marks)

B24ME4G36	INFORMATION TECHNOLOGY MANAGEMENT	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
		2	1	0	4	3	2024

Preamble

In the era of rapid digital transformation and technological advancement, engineers must understand not only technical systems but also how technologies are strategically managed within organizations. This course introduces fundamental concepts of technology and information technology management, including technology acquisition, innovation, strategy, policy, and sustainability considerations. This course equips final year students with managerial perspectives essential for functioning effectively in technology-driven and multidisciplinary environments.

Prerequisites

Nil

Course Outcomes

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

CO 1	Define and explain the fundamental concepts of technology and information technology management in organizations. (Cognitive Knowledge Level: Understand)
CO 2	Describe methods of technology acquisition, forecasting, and emerging technology trends. (Cognitive Knowledge Level: Understand)
CO 3	Explain technology strategy, adoption processes, and national policy initiatives related to science and technology. (Cognitive Knowledge Level: Understand)
CO 4	Summarize the role of R&D, innovation management, and intellectual property rights in technology-driven enterprises. (Cognitive Knowledge Level: Understand)
CO 5	Explain the human, ethical, environmental, and sustainability aspects associated with technology deployment. (Cognitive Knowledge Level: Understand)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	2	1	–	–	1	–	–	–	–	1	1
CO 2	2	2	–	–	1	–	–	–	–	1	2
CO 3	2	2	1	–	–	2	1	–	–	1	2
CO 4	1	1	1	–	–	–	2	–	–	1	2
CO 5	–	1	–	–	–	3	3	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	60	60	60
Apply			
Analyse			
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment : 10 marks
Self-Study (Quiz/ Seminar/ Microproject/
Video Assignments/ Analytical Assignments) : 5 marks

End Semester Examination Pattern

The end semester exam will carry 100 marks. There will be two parts; Part A and Part B. Part A contains 10 questions (2 questions from each module), of 3 marks each and the student should answer all the questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum of 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1: Foundations of Technology Management (6 hours)

Foundations of technology management – technology evolution and growth across engineering sectors – concepts and definitions of technology management – role and significance of technology in manufacturing, services, and digital industries – impact of technology on society and business – technology and competitive advantage – organizing technology at the enterprise level – key issues in managing technological innovation – forms of technology: process technology, product technology, and information technology – digital transformation fundamentals – strategic alignment of technology with business goals.

Module 2: Technology Acquisition and Foresight (7 hours)

Technology acquisition – new technology development – alternatives for acquiring new technologies (in-house development, collaboration, outsourcing, licensing) – management of acquired technology – technology forecasting: characteristics, principles, and process – need and role of forecasting in strategic planning – forecasting methods and techniques – planning and forecasting applications – technology generation and development processes – importance of technology development– emerging technologies landscape (AI, IoT, advanced manufacturing, digital platforms)–horizon scanning & identification of disruptive technologies

Module 3: Information Technology Management (8 hours)

Role of Information Technology (IT) in modern organizations – IT as a strategic resource – IT infrastructure and enterprise systems (ERP, SCM, CRM – overview) – IT strategy and business alignment – IT governance concepts – digital transformation and Industry 4.0 – management of IT projects – data management and cybersecurity basics – cloud computing and digital platforms – adoption and diffusion of IT in organizations – productivity and competitiveness impacts of IT – national digital initiatives and policies in India – ethical and sustainability issues in IT deployment.

Module 4: Managing R&D and Innovation (8 hours)

Role and importance of R&D in industry – corporate research and product/service lifecycle – R&D and cost competitiveness relationships – translation of R&D outputs into technology – innovation concepts and types (product, process, service, digital innovation) – distinction between innovation and invention – frameworks for innovation management – organizational characteristics supporting innovation – intellectual property rights: trademarks, copyrights, patents, infringement and remedies – technology transfer and commercialization – role of government in innovation ecosystem – globalization and innovation challenges – case studies on R&D and innovation management – agile and adaptive innovation management approaches.

Module 5: Human and Environmental Aspects (7 hours)

People and technology integration – human factors in technology management – organizational and psychological factors – technology and organizational structure – implications of technological change and digitalization – automation and rationalization in the Indian context – HRM issues in R&D and innovation teams – technology assessment – environmental impact analysis – circular economy principles – green and sustainable technology management – social responsibility and ethical considerations in technology deployment.

Textbooks

1. Tarek Khalil, *Management of Technology: The Key to Competitiveness*, McGraw-Hill.
2. V. K. Narayanan, *Managing Technology and Innovation for Competitive Advantage*, Pearson.
3. Pradip N. Khandwalla, *Fourth Eye: Excellence Through Creativity*, Wheeler Publishing.

References

1. Frederick Betz, *Managing Technological Innovation: Competitive Advantage from Change*, Wiley.
2. Joseph Schumpeter, *Capitalism, Socialism and Democracy*, Routledge.
3. R. G. Desai, *Technology and Society*, Himalaya Publishing House.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures/ Tutorial hours
	Module 1	**6**
1.1	Introduction to Technology Management; Evolution of technology across engineering sectors; Concepts and definitions; Forms of technology – product, process and information technology.	2
1.2	Role and significance of technology in manufacturing, services and digital industries; Technology and competitive advantage; Impact of technology on society and business.	2
1.3	Organizing technology at enterprise level; Managing technological innovation – key issues; Digital transformation fundamentals; Strategic alignment of technology with business goals.	2
	Module 2	**7**
2.1	Technology acquisition strategies – in-house development, collaboration, outsourcing and licensing; Management of acquired technology.	2
2.2	Technology forecasting – characteristics, principles and process; Role of forecasting in strategic planning; Forecasting methods and techniques.	2
2.3	Technology generation and development processes; Importance of technology development; Emerging technologies landscape – AI, IoT, advanced manufacturing and digital platforms.	2
2.4	Horizon scanning; Identification of disruptive technologies; Case discussion on emerging technology adoption.	1
	Module 3	**8**
3.1	Role of Information Technology in modern organizations; IT as a strategic resource; IT infrastructure fundamentals; Overview of ERP, SCM and CRM systems.	2

3.2	IT strategy and business alignment; IT governance concepts; Digital transformation and Industry 4.0.	2
3.3	IT project management fundamentals; Cloud computing and digital platforms; Data management and cybersecurity basics.	2
3.4	Adoption and diffusion of IT; Productivity and competitiveness impacts; National digital initiatives and IT policies in India; Ethical and sustainability issues in IT deployment.	2
	Module 4	**8**
4.1	Role and importance of R&D in industry; Corporate research and product/service lifecycle; R&D and cost competitiveness relationships.	2
4.2	Innovation concepts and types; Innovation vs invention; Frameworks for innovation management	2
4.3	Organizational characteristics supporting innovation; Intellectual Property Rights – patents, copyrights, trademarks; Infringement and remedies.	2
4.4	Technology transfer and commercialization; Role of government in innovation ecosystem; Globalization and innovation challenges; Agile and adaptive innovation approaches; Case discussion	2
	Module 5	**7**
5.1	People and technology integration; Human factors in technology management; Organizational and psychological factors.	2
5.2	Implications of technological change and digitalization; Automation and rationalization in Indian context; HRM issues in R&D and innovation teams.	2
5.3	Technology assessment; Environmental impact analysis; Circular economy principles; Green and sustainable technology management; Social responsibility and ethical considerations.	2
5.4	Module discussion, sustainability case analysis and review.	1
	Total	**36 hours**

CO ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Define Technology Management.
2. List the different forms of technology with examples.
3. Explain the evolution of technology management and discuss its relevance across engineering sectors.
4. Discuss the role of technology in achieving competitive advantage with suitable examples.

Course Outcome 2 (CO2):

1. What is technology acquisition?
2. List any three technology forecasting methods.
3. Discuss various alternatives for acquiring new technologies and their advantages and limitations.
4. Explain technology forecasting in detail, including principles, process, and applications.

Course Outcome 3 (CO3):

1. Define IT governance.
2. What is ERP? State its benefits.
3. Explain the role of IT as a strategic resource in modern organizations.
4. Discuss IT infrastructure and enterprise systems (ERP, SCM, CRM) in detail.

Course Outcome 4 (CO4):

1. Differentiate between invention and innovation.
2. What are the types of innovation?
3. Explain the role and importance of R&D in organizational competitiveness.
4. Discuss innovation management frameworks and organizational characteristics supporting innovation.

Course Outcome 5 (CO5)

1. Define technology assessment.
2. What is circular economy?
3. Explain the human factors influencing technology management and adoption.
4. Discuss the implications of automation and digitalization in the Indian context.

MODEL QUESTION PAPER

QP CODE: Pages: 2

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

EIGHTH SEMESTER B TECH DEGREE EXAMINATION, MAY 2028

Course Code: **B24ME4G38**

Course Name: **INFORMATION TECHNOLOGY MANAGEMENT**

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions. Each question carries 3 marks.

1. What is digital transformation?
2. State any three key issues in managing technological innovation.
3. Define horizon scanning.
4. Mention any three emerging technologies influencing industries today.
5. What is meant by IT strategy alignment?
6. Mention any three national digital initiatives in India.
7. Define Intellectual Property Rights (IPR).
8. What is technology transfer?
9. State any three HRM issues in innovation teams.
10. List any three environmental impacts of technological development.

PART B

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

Module 1

11. Explain how technology is organized at the enterprise level and aligned with business strategy. (14 marks)

OR

12. Elaborate on digital transformation and its impact on society and business. (14marks)

Module 2

13. Describe the process of technology generation and development. (14marks)

OR

14. Discuss emerging technologies and explain how organizations identify disruptive technologies. (14marks)

Module 3

15. Explain IT governance, digital transformation, and Industry 4.0 concepts. (14marks)

OR

16. Discuss data management, cybersecurity, and ethical issues in IT deployment. (14marks)

Module 4

17. Explain various forms of Intellectual Property Rights and remedies for infringement. (14marks)

OR

18. Discuss technology transfer, commercialization, and agile innovation approaches. (14marks)

Module 5

19. Elaborate on environmental impact analysis and green technology management. (14 marks)

OR

20. Discuss social responsibility and ethical considerations in technology deployment. (14 marks)

B24ME4L13	PROJECT PHASE II	Category: PWS	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: Analyze).
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)

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

PROJECT PHASE II Targets

- In-depth study and refinement of the topic based on Phase-I report.
- Review and finalization of problem approach/methodology.
- Detailed action plan with timelines, resource allocation, and teamwork.
- Comprehensive analysis, modeling, simulation, design, experimentation, prototype development, testing, and validation.
- Final product/process development, results analysis, conclusions, future directions (with SDG alignment where applicable).
- Preparation of conference/journal paper (if feasible).
- Presentation in university/state/national/international project expos.
- IPR filing (patent/publication) if applicable.
- Standard-format report preparation for departmental assessment.
- Final presentation and viva-voce with external expert.

Evaluation Guidelines & Rubrics Total: 150 marks (Minimum to pass: 75 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 Evaluation committee: Project coordinator, industry/research/academic external expert, senior faculty from sister department.

Evaluation by the Guide (30 Marks)

- **Project Scheduling & Work Distribution** (5): Detailed timelines, WBS, balanced allocation.
- **Literature Survey** (4): Outstanding depth/breadth (updated from Phase-I).
- **Student's Diary/Daily Log** (7): Regular signed records of progress, observations, sketches, reflections; promotes documentation and reasoning.
- **Individual Contribution** (9): Evidence of meaningful, equitable input per student.
- **Project Completion/Demonstration** (5): Functional prototype/demo to guide; objectives met, results verified.

Rubrics for evaluation by the Guide

Aspect / Parameter	Marks	Poor (0-1 for 5-mark items; 0-2 for 7-9 mark items)	Fair (2 for 5-mark; 3-4 for 7-9 mark)	Very Good (3-4 for 5-mark; 5-7 for 7-9 mark)	Outstanding (5 for 5-mark; 8-9 for 7-9 mark; full for others)
Project Scheduling & Distribution of Work among Team members [CO3, CO4 / PO8, PO10]	5	No meaningful scheduling or WBS; tasks unclear, unbalanced, or not assigned; no evidence of planning from Phase I.	Basic scheduling exists but incomplete/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.
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.

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)
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.

No.	Parameter	Marks	Poor (0-1)	Fair (2-3)	Very Good (4)	Outstanding (5)
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.
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.

No.	Parameter	Marks	Poor (0-3)	Fair (4-6)	Very Good (7-9)	Outstanding (10)
2-k	Relevance to societal/industrial /SDG needs [CO2/PO3/PO6] (Group)	5	No clear relevance.	Some relevance; limited translation to specs.	Strong relevance; problem solved with societal/SDG considerations.	Exceptional impact; outstanding contribution to sustainable/societal challenges.
2-l	Innovation/Novelty/Creativity [CO5/PO3] (Group)	5	Routine; no originality.	Limited freshness.	Good ingenuity; implementable with improvements.	Highly novel/ingenious; publishable/IPR potential.
2-m	Quality of results/conclusions/solutions [CO1/CO5/PO2/PO4] (Group)	10	None achieved; no valid conclusions.	Few achieved; limited analysis.	Many achieved; good inferences/suggestions.	Most achieved; extensive validation; clear future directions/SDG alignment.
2-n	Presentation/Communication [CO5/PO9] (Group/Individual)	10	Poor organization/delivery.	Needs improvement.	Good flow/professionalism.	Exceptional clarity/confidence; engaging technical communication.

Rubrics for Report Evaluation (25 Marks)

Sl. No.	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.

B24MEML1	MINOR PROJECT	Category: PWS	L	T	P	S	CREDIT	YEAR OF INTRODUCTION
			0	0	3	12	6	2024

Preamble:

This course is intended to provide students with an opportunity to apply the theoretical concepts acquired during their programme to the design and development of a functional engineering solution. The mini project enables students to gain hands-on experience in project planning, execution, documentation, and teamwork while addressing a real-world problem. Through the development of a moderately complex hardware or hardware–software system, students are encouraged to demonstrate creativity, technical competence, and the ability to develop sustainable and practical solutions.

Course Plan:

In groups of up to 4 students, design and develop a moderately complex system that addresses a real-world need or application (a functional working prototype/model is required). The project must meaningfully incorporate fundamental product design principles, including innovation, reliability, and aesthetics/ergonomics.

Students (in consultation with faculty/advisor):

- Identify topic of interest.
- Conduct literature review and gather information.
- State objectives and develop methodology.
- Perform design/fabrication/coding/programming.
- Demonstrate novelty/results/outputs (with SDG alignment where applicable).

Progress evaluated via minimum two reviews by committee (constituted by HoD). Submit project report at semester end. Demonstrate product against full specifications. Weightage given to innovative concepts, reliability, aesthetics/ergonomics, and societal/SDG relevance.

Course Outcomes [COs]: After completion, students 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/findings effectively (written/oral) (Cognitive Knowledge Level: Apply).

Mapping of Course Outcomes with Program Outcomes (POs)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO 1	3	3	3	2	2	3	1	1	1	1	2
CO 2	3	3	3	2	1	3	1	1	1	2	2
CO 3	3	3	3	2	2	3	1	1	1	1	2
CO 4						1	2	3	2	3	2
CO 5					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
- 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 guide (regular monitoring, involvement, progress).

Parameter	Marks (out of 15)	Poor (0-3)	Fair (4-7)	Good (8-11)	Very Good (12-14)	Outstanding (15)
Project Planning, Scheduling & Task Distribution [CO4/PO8, PO10]	4	No plan/WBS; unbalanced/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.

Parameter	Marks (out of 15)	Poor (0-3)	Fair (4-7)	Good (8-11)	Very Good (12-14)	Outstanding (15)
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).

Parameter	Marks (out of 40)	Poor (0-10)	Fair (11-20)	Good (21-28)	Very Good (29-35)	Outstanding (36-40)
Technical Depth & Justification [CO1-CO3 / PO1-PO4]	15	Superficial; no justification/ gaps.	Basic explanation; limited depth.	Reasonable justification; some analysis.	Strong technical discussion/systematic approach.	Excellent depth; critical analysis; innovative/SDG-aligned.
Innovation & Practical Relevance [CO1, CO3 / PO3, PO6]	10	No novelty; routine.	Limited innovation.	Some novelty/practical aspects.	Good innovation; practical/SDG relevance.	Highly innovative; strong societal/SDG impact.
Team Work & Involvement [CO4 / PO8]	8	Poor collaboration.	Uneven involvement.	Good team effort.	Strong collaboration.	Exemplary teamwork/leadership.
Communication & Presentation Readiness [CO5 / PO9]	7	Poor clarity.	Needs improvement.	Adequate.	Clear & structured.	Professional & confident.

3. ESE Components – Enhanced Rubrics (75 Marks Total)

- **Level of Completion (10 Marks)** [CO1-CO3]
  - Poor (0-2) : Incomplete; major unfinished parts.
  - Fair (3-5) : Partially complete; significant gaps.

- Good (6-7) : Mostly complete; minor issues.
- Very Good (8) : Fully complete with good quality.
- Outstanding (9-10) : Exceptionally complete; exceeds expectations (innovative/SDG features).

- **Demonstration of Functionality/Specifications (25 Marks)** [CO1, CO3 / PO3]
  - Poor (0-6) : Non-functional; fails specs.
  - Fair (7-12) : Basic functionality; many failures.
  - Good (13-18) : Functional; meets most specs with issues.
  - Very Good (19-22) : Reliable demo; meets all key specs.
  - Outstanding (23-25) : Flawless; innovative features; reliable/SDG-aligned performance.

- **Project Report (10 Marks – CIE + ESE combined consideration)** [CO5 / PO9]
  - Poor (0-2) : Poor organization; incomplete/missing sections.
  - Fair (3-5) : Basic format; language/references weak.
  - Good (6-7) : Systematic; mostly consistent.
  - Very Good (8) : Well-organized; good references.
  - Outstanding (9-10) : Professional; excellent structure/readability; proper citations/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.
  - Good (11-14) : Answers most questions reasonably.
  - Very Good (15-17) : Confident; good depth/explanation.
  - Outstanding (18-20) : Excellent articulation; integrates concepts; handles challenges fluently.

- **Presentation (10 Marks)** [CO5 / PO9]
  - Poor (0-2) : Poor delivery/structure.
  - Fair (3-5) : Needs major improvement.
  - Good (6-7) : Clear & logical.
  - Very Good (8) : Professional flow.
  - Outstanding (9-10) : Engaging, confident; excellent visuals/technical clarity.

B24MEHL1	HONORS PROJECT	Category: PWS	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.

Course Plan

- Identify advanced core engineering branch topic in consultation with faculty/advisor.
- Conduct in-depth literature review and gap analysis.
- State objectives, develop systematic methodology (with SDG alignment where relevant).
- Design/fabricate/develop hardware/software/codes, implement, test, refine.
- Demonstrate novelty, functionality, reliability, aesthetics/ergonomics through results/outputs.
- Progress evaluated via minimum two reviews by committee.
- Submit comprehensive project report; demonstrate full design specifications.
- Explore conference/journal publication or IPR filing.

Course Outcomes [COs]

CO1	Apply and extend acquired knowledge in selected core engineering branch /technology area for advanced Honours project development (Cognitive Knowledge Level: Apply).
CO2	Identify, discuss, justify, and systematically approach technical/design aspects of innovative projects with SDG/societal relevance (Cognitive Knowledge Level: Analyze).
CO3	Reproduce, improve, refine, and validate technical solutions for complex engineering projects (Cognitive Knowledge Level: Apply/Analyze).
CO4	Collaborate effectively as a team in development and management of advanced technical projects (Cognitive Knowledge Level: Apply).
CO5	Communicate and report project activities, findings, and innovations effectively (written/oral) (Cognitive Knowledge Level: Apply).

Mapping of Course Outcomes with Program Outcomes (POs)

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

Evaluation Scheme (Maintained as per attached document)

Total: 150 marks (CIE 75 + ESE 75; ESE duration 1 hour). Evaluation by 3-member committee (HoD/senior faculty, academic/program coordinator, project guide/coordinator). Committee assesses completion, functionality/specs demonstration, presentation, viva, knowledge, involvement.

Split-up of CIE (75 Marks)

- Attendance : 10
- Marks 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 (Progressive levels tied to COs/POs/SDGs; evidence-based for fairness)

1. Guide's Evaluation (CIE – 15 Marks) Holistic assessment via regular monitoring, logs, contribution, progress.

Aspect	Marks	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.

Aspect	Marks	Poor (0–3)	Fair (4–7)	Good (8–11)	Very Good (12–14)	Outstanding (15)
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	Major gaps; no justification/SDG.	Basic; limited analysis.	Reasonable; some justification.	Strong/systematic/SDG-linked.	Exceptional depth; innovative/refined/SDG-impact.
Teamwork / Involvement [CO4 / PO8]	10	Uneven/no collaboration.	Limited equity.	Good teamwork.	Effective/collaborative.	Outstanding leadership/equity.
Interim Progress / Functionality [CO3 / PO3, PO5]	15	No demo/progress.	Partial/unreliable.	Good interim results.	Advanced/reliable.	Highly innovative/validation/SDG relevance.

3. ESE – Level of Completion (10 Marks)

Poor (0–2) : Incomplete/no model. Fair (3–4): Basic; major gaps.

Good (5–6) : Most features done.

Very Good (7–8) : Near-full; minor issues.

Outstanding (9–10) : Fully advanced; exceeds specs/SDG innovation.

4. ESE – Demonstration of Functionality (25 Marks)

Poor (0–5) : Non-functional.

Fair (6–10) : Partial/unreliable.

Good (11–15) : Functional basics.

Very Good (16–20) : Reliable/meets most specs.

Outstanding (21–25) : Fully functional; innovative/reliable/SDG-aligned.

5. ESE – Project Report (10 Marks) (CIE+ESE combined)

Poor (0–2)	: Poor/no references.
Fair (3–4)	: Basic/inconsistent.
Good (5–6)	: Systematic/good refs.
Very Good (7–8)	: Professional/SDG discussion.
Outstanding (9–10)	: Exemplary/publishable.

6. ESE – Viva-voce (20 Marks)

Poor (0–4)	: No understanding.
Fair (5–8)	: Basic/prompting needed.
Good (9–12)	: Good grasp/explanation.
Very Good (13–16)	: Strong; handles questions.
Outstanding (17–20)	: Deep insight/integration/SDGs confidently.

7. ESE – Presentation (10 Marks)

Poor (0–2)	: Unclear/poor delivery.
Fair (3–4)	: Needs improvement.
Good (5–6)	: Clear/structured.
Very Good (7–8)	: Professional/confident.
Outstanding (9–10)	: Engaging/excellent visuals/communication.