Department of Mechanical Engineering
Faculty of Engineering and Technology, Jadavpur University

Curriculum and Syllabus

for

Bachelor of Engineering in Mechanical Engineering (BME) Programme

Programme Educational Objectives (PEOs):

Mechanical Engineering Graduates will be able to

PEO1: model, analyze and design mechanical processes and systems;

PEO2: take active role in the management of mechanical and allied systems;

PEO3: effectively participate in core and inter-disciplinary higher studies;

PEO4: work effectively as a leader or as a member of team in project execution;

PEO5: engage in ethical practice and lifelong learning and adapt to evolving professional challenges.

Programme Outcomes (POs):

Engineering Graduates will be able to:

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems. PO2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Specific Outcomes (PSOs):

Mechanical Engineering Graduates will be able to

PSO1: Hands on Training: work on, experiment with, control and manage machines, devices and mechanical systems.

PSO2: Real life problem solving: apply domain knowledge, mechanical engineering skill and allied soft skills towards solving real life industrial and research problems through curricular and co-curricular activities.

PSO3: Social outreach: identify and provide acceptable technological solutions to community specific problems through curricular, co-curricular and extracurricular activities.

Department of Mechanical Engineering
Faculty of Engineering and Technology, Jadavpur University
Curriculum for Bachelor of Engineering in Mechanical Engineering (BME): UG Engineering Programme (4 Year)

1st Year 1st Semester

Course Code	Course name	Category	Type	Contact L-T-P	Credit	Marks
ME(M2)/BS/B/MATH/T/111	Mathematics – I	BS	Basic	3-0-0	3	100
ME(M2)/BS/B/Ph/T/112	Physics	BS	Basic	3-0-0	3	100
ME(M2)/ES/B/ET/T/113	Electronics	ES	Basic	3-0-0	3	100
ME(M2)/ES/B/EE/T/114	Basic Electrical Engineering	ES	Basic	3-0-0	3	100
ME(M2)/ES/B/T/115	Engineering Mechanics: Statics	ES	Basic	3-0-0	3	100
ME(M2)/HS/B/HUM/T/116	Humanities and Sociology	HS	Basic	3-0-0	3	100
ME(M2)/ES/B/S/111	Engineering Drawing (Drawing board mode)	ES	Basic	0-0-3	1.5	100
ME(M2)/ES/B/S/112	Workshop Practice – I	ES	Basic	0-0-3	1.5	100
Total				18-0-6	21	800

1st Year 2nd Semester

Course code	Course name	Category	Type	Contact L-T-P	Credit	Marks
ME(M2)/BS/B/MATH/T/121	Mathematics – II	BS	Basic	3-0-0	3	100
ME(M2)/PC/B/EE /T/122	Electrical Machines	BS	Basic	3-0-0	3	100
ME(M2)/PC/B/T/123	Strength of Materials	PC	Basic	3-0-0	3	100
ME(M2)/ES/B/T/124	Fluid Mechanics – I	ES	Basic	3-0-0	3	100
ME(M2)/ES/B/T/125	Thermodynamics	ES	Basic	3-0-0	3	100
ME(M2)/ES/B/S/121	Descriptive Geometry and Surface Development	ES	Basic	0-0-3	1.5	100
ME(M2)/ES/B/S/122	Computer Programming	ES	Basic	0-0-3	1.5	100
ME(M2)/ES/B/S/123	Workshop Practice – II	ES	Basic	0-0-3	1.5	100

ME(M2)/ES/B/EE&ET/S/124	Electrical Technology Lab	ES	Basic	0-0-3	1.5	100
MC/TS/P101	Technical Communicative English & Soft Skill	MC	Basic	0-0-3	0	0
Total				15-0-12	21	900

1st Year 2nd Semester

Course code	Course name	Category	Type	Contact L-T-P	Credit	Marks
ME(M2)/BS/B/MATH/T/211	Mathematics – III	BS	Basic	3-0-0	3	100
ME(M2)/PC/B/T/212	Engineering Dynamics	PC	Basic	3-0-0	3	100
ME(M2)/PC/B/T/213	Fluid Mechanics – II	PC	Basic	3-0-0	3	100
ME(M2)/PC/B/T/214	Heat Transfer	PC	Basic	3-0-0	3	100
ME(M2)/PC/B/T/215	Material Science and Engineering	PC	Basic	3-0-0	3	100
ME(M2)/PC/B/S/211	Computer Aided Drafting	PC	Basic	0-0-3	1.5	100
ME(M2)/PC/B/S/212	Machine Drawing – I (Drawing board mode)	PC	Basic	0-0-3	1.5	100
ME(M2)/PC/B/S/213	Electrical Technology Lab.(II)	PC	Basic	0-0-3	1.5	100
ME(M2)/BS/B/S/214	Numerical Analysis	BS	Basic	0-0-3	1.5	100
Total				15-0-12	21	900

2nd Year 2nd Semester

Course code	Course name	Category	Type	Contact L-T-P	Credit	Marks
ME(M2)/BS/B/MATH/T/221	Mathematics – IV	BS	Basic	3-0-0	3	100
ME(M2)/PC/B/T/222	Fluid Machinery – I	PC	Basic	3-0-0	3	100
ME(M2)/PC/B/T/223	Advanced Engineering Mechanics	PC	Basic	3-0-0	3	100

ME(M2)/PC/B/T/224	Kinematic Analysis and Synthesis	PC	Basic	3-0-0	3	100
ME(M2)/PC/B/T/225	Design of Machine Elements – I	PC	Basic	3-0-0	3	100
ME(M2)/PC/B/T/226	Manufacturing Processes	PC	Basic	3-0-0	3	100
ME(M2)/PC/B/S/221	Machine Drawing – II (Computer Terminal Mode)	PC	Basic	0-0-3	1.5	100
ME(M2)/PC/B/S/222	Fluid Mechanics Lab	ES	Basic	0-0-3	1.5	100
ME(M2)/PC/B/S/223	Heat Power Lab. – I (Thermo. & Heat Transfer)	PC	Basic	0-0-2	1	100
ME(M2)/PC/B/S/224	Applied Mechanics Lab. – I	PC	Basic	0-0-2	1	100
ME(M2)/PC/B/S/225	Workshop Practice – III	PC	Basic	0-0-3	1.5	100
Total				18-0-13	24.5	1100

3rd Year 1st Semester

Course code	Course name	Category	Type	Contact L-T-P	Credit	Marks
ME(M2)/PC/B/T/311	Fluid Machinery – II	PC	Basic	3-0-0	3	100
ME(M2)/PC/B/T/312	Dynamics of Machines	PC	Basic	3-0-0	3	100
ME(M2)/PC/B/T/313	Internal Combustion Engine	PC	Basic	3-0-0	3	100
ME(M2)/PC/B/T/314	Design of Machine Elements – II	PC	Basic	3-0-0	3	100
ME(M2)/PC/B/T/315	Machining Technology and Metrology	PC	Basic	3-0-0	3	100
ME(M2)/PE/B/T/316	Basic Professional Elective – I	PE	Basic	3-0-0	3	100
ME(M2)/PC/B/S/311	Workshop Practice – IVA	PC	Basic	0-0-3	1.5	100
ME(M2)/PC/B/S/312	Metrology and Metallography Lab. A	PC	Basic	0-0-2	1	100
ME(M2)/PC/B/S/313	Applied Mechanics Lab. – II	PC	Basic	0-0-2	1	100
ME(M2)/PR/B/S/314	Minor Project	PS	Basic	0-0-3	1.5	100
Total				18-0-10	23	900

Basic Professional Elective – I ME(M2)/PE/B/T/316	
A.	Introduction To Finite Element Method
B.	Optimization Techniques For Engineering Design
C.	Vehicle Dynamics And Automotive Suspension System
D.	Numerical Heat Transfer
E.	Solar Energy
F.	Elements Of Computational Fluid Dynamics
G.	Mechanical Measurement And Industrial Statistics
H.	Mathematical Method for Engineers
I.	Introduction to Composite Structures

3rd Year 2nd Semester

Course code	Course name	Category	Type	Contact L-T-P	Credit	Marks
ME(M2)/PC/B/T/321	Energy Conversion System	PC	Basic	3-0-0	3	100
ME(M2)/H/B/T/322	Industrial Management	H	Hons	3-0-0	3	100
ME(M2)/PC/B/T/323	Design of Machine Elements – III	PC	Basic	3-0-0	3	100
ME(M2)/PC/B/T/324	Electrohydraulic Control Systems	PC	Basic	3-0-0	3	100
ME(M2)/PE/B/T/325	Basic Professional Elective – II	PE	Basic	3-0-0	3	100
ME(M2)/PC/B/TS/326	Measurement & Instrumentation	PC	Basic	2-0-2	3	100
ME(M2)/PC/B/S/321	Workshop Practice – IVB	PC	Basic	0-0-3	1.5	100
ME(M2)/PC/B/S/322	Metrology and Metallography Lab. B	PC	Basic	0-0-2	1	100

ME(M2)/PC/B/S/323	Machine Design Sessional	PC	Basic	0-0-3	1.5	100
ME(M2)/PC/B/S/324	Fluid Machinery Lab.	PC	Basic	0-0-3	1.5	100
Total				17-0-13	23.5	1000

Basic Professional Elective – II ME(M2)/PE/B/T/325	
A.	Mechanical Vibration Analysis
B.	Dynamics And Control Of Electromechanical Systems
C.	Principles Of Engineering Tribology
D.	Extended Surface Heat Transfer
E.	Energy Conservation And Management
F.	Combustion Engineering
G.	Aerodynamics
H.	Advanced Production Processes
I.	Quantity Production Methods
J.	Laser Machining Process

4th Year 1st Semester

Course code	**Course name**	**Category**	**Type**	**Contact L-T-P**	**Credit**	**Marks**
ME(M2)/PC/B/T/411	Design of Machine Elements – IV	PC	Basic	3-0-0	3	100
ME(M2)/PC/B/T/412	Refrigeration and Air Conditioning	PC	Basic	3-0-0	3	100
ME(M2)/PC/B/T/413	Metal Cutting and Machine Tools	PC	Basic	3-0-0	3	100

ME(M2)/PE/H/T/414	Hons Professional Elective – I	PE	Hons	4-0-0	4	100
ME(M2)/PE/H/T/415	Hons Professional Elective – II	PE	Hons	4-0-0	4	100
ME(M2)/PE/H/T/416	Hons Professional Elective – III NOT specialization specific	PE	Hons	4-0-0	4	100
ME(M2)/PS/B/S/411	Workshop Practice VA	PS	Basic	0-0-3	1.5	100
ME(M2)/PC/B/S/412	Heat Power Lab. – II (Devices)	PC	Basic	0-0-2	1	100
ME(M2)/PR/B/S/413	Colloquium	PS	Basic	0-0-3	1.5	100
ME(M2)/PR/B/S/414	Project (Major)	PS	Basic	0-0-3	1.5	100
Total				21-0-11	26.5	1000

Hons Professional Elective – I **ME(M2)/PE/H/T/414**	
A.	Finite Element Method For Nonstructural Applications
B.	Theory Of Pressure Vessels
C.	Plastics, Polymers, Composites And Ceramics Materials
D.	Advanced Heat Transfer
E.	Steam Turbine
F.	Advanced Automotive Engines
G.	Introduction To Turbulent Fluid Flow
H.	Theory Of Metal Forming
I.	Production Systems And Controls
J.	Design of Thermal systems
K.	Gas Turbines
L.	Thermal Turbo Machines

Hons Professional Elective – II **ME(M2)/PE/H/T/415**	
A.	Elements Of Fracture Mechanics
B.	Design Methodology For Fracture, Fatigue And Creep
C.	Dynamics Of Thermal Systems
D.	Steam Generators
E.	Bio-Heat Transfer
F.	Hydro, Wind And Wave Power
G.	Total Quality Management And Six Sigma

Hons Professional Elective – III **ME(M2)/PE/H/T/416**	
A.	Mathematical Methods in Mechanical Engineering
B.	Hybrid and Electric Vehicles
C.	Continuum Mechanics
D.	Mechatronics
E.	Sustainable Engineering
F.	Atmospheric Fluid Dynamics
G.	Reliability in Engineering Design
H.	Experimental methods and Data analysis

4th Year 2nd Semester

Course code	Course name	Category	Type	Contact L-T-P	Credit	Marks
ME(M2)/HS/B/T/421	Engineering Economics and Costing	HS	Basic	3-0-0	3	100
ME(M2)/PC/B/T/422	Material Handling	PC	Basic	3-0-0	3	100
	Basic Open Elective – I	OE	Basic	3-0-0	3	100
ME(M2)/PE/H/T/424	Hons Professional Elective – IV	PE	Hons	4-0-0	4	100
ME(M2)/PS/B/S/421	Workshop Practice – VB	PS	Basic	0-0-3	1.5	100
ME(M2)/PC/B/S/422	Machine Elements Lab	PC	Basic	0-0-2	1	100
ME(M2)/PR/B/S/423	Project (Major)	PS	Basic	0-0-3	1.5	100
ME(M2)/PC/H/S/424	Advanced Laboratory and Simulation	PC	Hons	0-2-4	4	100
Total				13-0-12	24	800

Hons Professional Elective – IV ME(M2)/PE/H/T/424	
A.	Finite Elements For Dynamics And Non-Linearity
B.	Reliability and Quality Engineering Design
C.	Robotics
D.	Introduction To Nonlinear Oscillations
E.	Advanced Thermodynamics
F.	Advanced Power Generation
G.	Nuclear Power Engineering
H.	Introduction To Modern Control Theory
I.	Maintenance And Safety Engineering

Department of Mechanical Engineering
Faculty of Engineering and Technology, Jadavpur University
Bachelor of Engineering Mechanical Engineering (BME) Programme (4 Year)

Syllabus

1st Year 1st Semester

Course Code: ME(M2)/BS/B/MATH/T/111	Course Name: Mathematics - I	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: BS	Nature of Course: Theoretical	

Course content/Syllabus:

Module 1

Differential Calculus of Single Variables: (Marks: 30)

Sequence; Infinite series and their convergence and divergence; Cauchy's general principle of convergence; Comparison test; D'Alembert's ratio test and Cauchy's root (statement and their applications only); Successive differentiation; Rolle's theorem*; Mean value theorems; Taylor's theorem*; Maclaurin's theorem*; Expansion of elementary functions; Indeterminate form; Curvature and Asymptote; Concavity, convexity and points of inflexion.

Differential Calculus of Several Variables: (Marks: 20)

Limit; Continuity and Differentiability; Directional derivatives; Partial derivatives; Differentials; Euler's theorem on homogeneous functions; Implicit Functions; Jacobian; Taylor's theorem*, Maxima; Minima and Lagrange's method of undetermined multipliers.

* Proof not required.

Module 2

Integral Calculus: (Marks: 50)

Riemann integration (Definition and properties); Fundamental theorem of integral calculus; First Mean value theorem of integral calculus; Improper integrals (Definitions and examples); Gamma and Beta functions; Multiple integrals; Rectification; Quadrature; Volume and surface areas of solids of revolution; Numerical integration by trapezoidal and Simpson's 1/3 rule.

Course Outcomes (COs):

The students of the course should be able to

CO1: Comprehend Taylor's theorem, Taylor's series, indeterminate forms, convergence of infinite series (K1)

CO2: Estimate curvature, asymptote, concavity, convexity of functions (K2)

CO3 Define directional and partial derivatives of multi-variable functions (K1)

CO4: Explain maxima-minima problems (K2)

CO5: Describe fundamental theorem of integral calculus (K2)

CO6: Estimate multiple integrals, quadrature, volume integrations, numerical integrations (K2)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1												
CO2	3	2	1												
CO3	3	2	1												
CO4	3	2	1												
CO5	3	2	1												
CO6	3	2	1												

Course Code: ME(M2)/BS/B/Ph/T/112	Course Name: Physics	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: BS	Nature of Course: Theoretical	

Course content/Syllabus:	1. Simple Harmonic motion, free vibration, damped and forced vibration, resonance. Wave motion, Superposition principle, phase velocity and group velocity. (4) 2. Motion of fluid, Bernoulli's theorem, Poiseuille's equation for the flow of liquid through narrow tube, motion of a body through viscous medium, Stoke's law. (4) 3. Overview of Coulomb's law, Gauss's law, dielectric polarization, Displacement Vector, Overview of BiotSavart law and ampere's circuital law. (4) 4. Time–varying field, Farady's law of electromagnetic induction, Transient phenomena in electric circuits. (Series L-R, Series C-R). (4) 5. Maxwell's equations, wave equation, plane electromagnetic waves, energy momentum, Poynting's theorem, electromagnetic boundary conditions, reflection and refraction. (10) 6. Interference of light waves, Young's experiment, Spatial and temporal coherence, diffraction due to single slit and plane diffraction grating, Polarization of light waves , Polarization by reflection, Brewster's law. (9) 7. Wave particle duality, de Broglie waves and uncertainity principle, Concept of wave function and its physical interpretation. Normalization. I-D Schrodinger equation -1-D (infinite) potential well. (7)
Course Outcomes (COs):	The students of the course should be able to – CO1: Define SHM and vibration phenomena (K1)
	CO2: Describe various aspects of motions of fluid and related governing laws (K2) CO3: Describe laws of electric and magnetic fields and its governing laws (K2) CO4: Describe laws of electro-magnetic phenomenon, transient situations in electric circuits (K2) CO5: Define wave optics, wave-particle duality theory (K1) CO6: Define basics of quantum mechanics with one-dimensional Schrodinger equation (K1)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**	**1**												
CO2	**3**	**2**	**1**												
CO3	**3**	**2**	**1**												
CO4	**3**	**2**	**1**												
CO5	**3**	**2**	**1**												
CO6	**3**	**2**	**1**												

Course Code: ME(M2)/ES/B/ET/T/113	Course Name: Electronics	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: ES	Nature of Course: Theoretical	

Course content/Syllabus:	Review of the basics of semiconductor physics; N and P- type semiconductors; P-N junction and its V-I characteristics; Rectifier and filter circuits; Zener diodes, its V-I characteristics and applications. (5 periods) Junction transistors (NPN and PNP types); Symbolic representation of these transistors; Biasing of transistors; Their Input and out characteristics; DC load line, determination of Q-point and application of sinusoidal input signal, Common base, common emitter and common collector configurations; Voltage gain and power gain, Transistors as amplifiers, small signal analysis of BJT circuits (12 periods) Introduction to JFET and MOSFET characteristics (3 Periods) General theory of feedback, negative feed back and its advantages, Darlington connection Positive feedback, Requirement for oscillation; Phase shift oscillator R-C types. (8 periods) Transistor as a switch, Introduction to a stable, mono stable and bi-stable multi vibrators, Schmitt Trigger (4 periods) Introduction to linear integrated circuits, Operational amplifiers and its applications including inverting and non-inverting amplifiers, adders, subtractors, integrators etc. (4 periods) Combinational digital circuits; Logic systems and basic logic gates, truth table of each gate and their implementations, (4 periods) Introduction to non-linear integrated circuits, flip-flops, clock pulses. (2 Periods)

Course Outcomes (COs):	The students of the course should be able to CO1: Recall of the basics of semiconductor physics (K1) CO2: Describe the principles of basic electronic components and systems (K1) CO3: Illustrate basic electronic circuits (K2) CO4: Apply the principles of basic electronics to simple cases (K3)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**1**													
CO2	**3**	**2**													
CO3	**2**	**3**	**1**												
CO4	**2**	**3**	**1**												

Course Code: ME(M2)/ES/B/EE/T/114	Course Name: Basic Electrical Engineering	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: ES	Nature of Course: Theoretical	

Course content/Syllabus:	DC circuits: Superposition theorem, Kirchoff's Laws and Thevenin's theorem, Maximum power transfer, applications; delta-star and star-delta transformations. (6 Lectures) Electromagnetism: Review of magnetic flux, force on current carrying conductors, Fleming's right hand rule and Lenz's law. (3 lectures) Magnetic circuit: MMF, Flux, reluctance, B-H loop, Hysteresis and eddy current loss; Magnetic circuit analysis with an air gap. (6 lectures) Alternating voltage and current: Generation of alternating emf, average value, RMS value, Form factor, peak factor, representation of an alternating quantity by a phasor, addition and subtraction of phasors. Single phase circuits with R, L and C in parallel and series, resonance, power and power factor, complex notations, j operator, resistance, reactance and impedance, power and reactive volt-ampere. (10 lectures) Electrical Measurements: Measurement of resistance and inductance by using bridges, Principle of operation of moving coil and moving iron type instruments; DC and AC ammeters and voltmeters, Power factor meter and frequency meter, DC and AC Power measurement, Introduction to error analysis (6 lectures) Introduction to Primary sensing elements and transducers, Thermistors, opto-electronic devices like photodiodes, photo-voltaic cell (8 lectures)
	Introduction to Power system components, Switches, relays and circuit breakers (4 lectures)
Course Outcomes (COs):	The students of the course should be able to CO1: Describe the principles of electrical circuits and measurements (K1) CO2: Review the basics of Electromagnetism (K2) CO3: Interpret electrical circuits and its components (K2) CO4: Explain the principles of electrical measurement (K2) CO5: Apply the laws and principles to basic circuits (K3)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**													
CO2	**3**	**2**													
CO3	**3**	**2**													
CO4	**3**	**2**	**1**												
CO5	**2**	**3**	**1**												

Course Code: ME(M2)/ES/B/T/115	Course Name: Engineering Mechanics: Statics	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: ES	Nature of Course: Theoretical	

Course content/Syllabus:	Application of vector algebra for various kinds of force system; equivalent force system. Equilibrium of rigid bodies under two-dimensional and three-dimensional force systems: concept of free body diagrams; equilibrium problems for trusses, frames, cables. Simple problems of dry friction; application of dry friction in engineering configuration like wedges, square threaded screw, flexible belt and pulley. Properties of surface—centroids of simple and composite plane figures; Pappus theorem and its application; area moment of inertia of simple and composite plane figures, product moment of inertia for area of plane figures; parallel axes theorem; rotation of axes. Principle of virtual work for rigid bodies in static equilibrium.

Course Outcomes (COs):	CO1: Describe various force systems (coplanar and spatial) and its resultants in relation with engineering configurations. CO2: Describe the concepts to solve simple engineering problems related to static equilibrium. CO3: Solve problems related to simple friction and machine friction. CO4: Solve problems related to properties of surfaces.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3													
CO2	3	3													
CO3	2	3													
CO4	2	3		1											

Course Code: ME(M2)/HS/B/HUM/T/116	Course Name: Humanities and Sociology	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: HS	Nature of Course: Theoretical	

Course content/Syllabus:

1. **Evolution of science and technology [5L]**

Readings:

'The prehistory of science and technology studies' in Sismondo, Sergio , *An Introduction to Science and Technology Studies*, Wiley Blackwell. Second Edition)

'The Kuhnian revolution' in Sismondo, Sergio, *An Introduction to Science and Technology Studies*, Wiley Blackwell, Second Edition)

2. **Civilization and approaches in society and technology [8L]** Readings:

'Indigenous Medicine and Medical Science' in P K Bose ,*Health and Society in Bengal*, Sage.

'Introduction: Science as a Reason of State' in Ashis Nandy, (ed.) *Science, Hegemony and Violence A Requiem For Modernity*

3. **Science and technology revolution [4L]**

Readings:

'Industrial Revolution and Scientific and Technological Progress' Rainer Fremdling

4. **Emergence of industrial society [6L]** Readings:

'The Industrial Revolution' in Eric Hobsbawm. The *Age of Revolution 1789-184*8

5. **Development of occupation and profession [4L]** Readings:

'Technological change and life on the job' in Volti R, *Society And Technological Change*, World Publishers, 6th edition)

'Occupations and society' in Watson T, *Sociology, Work and Industry* Fourth edition, Routledge

Gendering of Technology

Feminism Confronts Technology by Judy Wajcman

6. **Post-industrial society [10L]** Readings:

'Post-industrial society' in Webstar Frank, *Theories of the information society*, Routledge, third edition, 2006

'What is an information society' in Webstar Frank, *Theories of the information society,* Routledge, third edition, 2006)

'Network society' in Webstar Frank, *Theories of the information society*, Routledge, third edition, 2006)

'Information and post modernity' in Webstar Frank, *Theories of the information society*, Routledge, third edition, 2006)

Consumer society

Peter Corrigan, *The Sociology of Consumption: An Introduction, 1997.* Chapters 1 and 2.

Consumption practices of youth: Fashion, Dressing, and Tattooing.

Ecology GhoshAshish, T*echnology and Environment*

S. Erkman, *Industrial Ecology :an historical view*

Smart City

R H Holland, Critical Interventions into the Corporate Smart City, Cambridge Journal of Regions, *Economy and Society*, 2015, 8, 61-77

Chapters -'A Comprehensive View of the 21st century City: Smartnessas Technologies and Innovation in Urban Contexts' and 'Rethinking Learning in the Smart City: Innovating Through Involvement, Inclusivity, and Interactivities with Emerging Technologies' in Gil-Garcia, Pardo, Nam (eds.). *Smarter as the New Urban Agenda: A Comprehensive View of the 21st Century City*.

N. Jayaram, *Revisiting the City: The Relevance of Urban Sociology Today*. Springer

Course Outcomes (COs):	The students of the course should be able to – CO1: Trace the historical development of science and technology. CO2: Analyze diverse societal approaches to integrating science and technology. CO3: Evaluate significant revolutions in science and technology. CO4: Examine the socio-economic transformations associated with the emergence of industrial society.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						**3**	**1**	**1**		**1**		**1**			
CO2						**3**	**1**	**2**		**1**		**2**			
CO3						**3**	**1**	**1**		**1**		**1**			
CO4						**3**	**1**	**2**		**1**		**2**			

Course Code: ME(M2)/ES/B/S/111	Course Name: Engineering Drawing (Drawing Board Mode)	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: ES	Nature of Course: Sessional	
Course content/Syllabus:	Introduction and uses of drawing instruments, Different types of lines, IS conventions (BIS SP46: 2003), Engineering Lettering, Home assignment (3 hours) Standard practices and principles of dimensioning. Concept of scale, use of diagonal scale and scale of chord, Home assignment (3 hours) Geometrical Constructions: Regular polygons, conic sections, spirals, Sine Curve, Involutes, Rolling Curves, Home assignment (3 hours) Principles of orthographic projection: planes of projection (principal & auxiliary), object & viewer, lines of projection etc., angles of projection. Projections of points, lines and solids, Home assignment (3 hours) Orthographic projection drawing of simple objects: prisms, pyramids & sphere with and without auxiliary views. (6 hours) Orthographic projection of combination of simple objects with and without auxiliary views. (3 hours) Orthographic projection of machine parts (3 hours) Isometric projection: Isometric scale, Isometric drawings (6 hours) Third view development. (6 hours) Sectional views. (6 hours)	
Course Outcomes (COs):	The students of the course should be able to – CO1: Explain the significance of engineering drawing with reference to Mechanical Engineering and Indian Standard (BIS SP46: 1988). (K2, A1) CO2: Construct different geometrical shapes. (K2, S1, A1) CO3: Apply the concepts of orthographic projection to draw principal views of simple engineering objects. (K3, S2, A2) CO4: Apply the concepts of sectional views and isometric projection for simple engineering objects. (K3, S2, A2)	

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**					**1**		**1**		**1**	**1**		**1**		
CO2	**3**	**1**				**1**		**1**	**1**	**1**			**2**		
CO3	**3**	**2**				**1**		**1**	**1**	**1**			**2**		
CO4	**3**	**2**				**1**		**1**	**1**	**1**			**2**		

Course Code: ME(M2)/ES/B/S/112	Course Name: Workshop Practice - I	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: ES	Nature of Course: Sessional	
Course content/Syllabus:	Introduction to types of Indian woods used for engineering purposes and carpenter’s tools; use of wood working machines; making of selected joinery; Introduction to different phenomena arising out of shrinkage of castings and pattern maker’s rule; making of wooden patterns from supplied drawings and samples of patterns; making of core boxes.	

Course Outcomes (COs):	The students should be able to CO1: Recognize the usage of different tools and processes in carpentry and pattern making (K1, A1). CO2: Describe the required methods to form different type of joints. (K2) CO3: Accomplish assigned jobs within stipulated time. (S3). CO4: Adapt themselves in the workshop environment (A4, S4)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**	**1**										**1**		
CO2	**3**	**2**											**1**		
CO3	**1**	**1**	**1**						**3**		**1**		**2**	**1**	
CO4	**1**	**2**				**1**			**3**		**1**		**1**	**1**	

1st Year 2nd Semester

Course Code: ME(M2)/BS/B/MATH/T/121	Course Name: Mathematics - II	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: BS	Nature of Course: Theoretical	

Course content/Syllabus:	**Linear Algebra: (Marks: 25)** Matrix Determinant; Inverse of a square matrix ; Elementary row and column operations; Echelon form; rank of a matrix; Solution of a system of linear equations; Cramer's rule; matrix inversion method. Characteristic equations; Eigenvalues and Eigenvectors; Cayley-Hamilton theorem. **Geometry of Three Dimensions: (Marks:15)** Cartesian co-ordinates in three dimensions; Direction cosines; Angle between two lines; Equation oh planes and Straight lines; Skew lines; Shortest distance between skew lines; Condition of co-planarity; Standard equation of spheres. **Vector Algebra: (Marks:10)** Basics of vector algebra; Dot and Cross products of two vectors; Products of three or more vectors; Volume of tetrahedron; Work done; Moment; Angular Velocity. **Vector Calculus: (Marks:50)** Vector functions of a scalar variable; Limit; Continuity and Derivative of vector functions; Applications to mechanics ; Partial Derivatives of vector function of more than one variables; Directional derivative; Gradient; Divergence and Curl; Vector integration; Line integrals; Surface integrals and volume integrals; Green's theorem in the plane; Gauss theorem; Stokes's theorem and their applications; Tangent, Normal and Binormal of space curve; Serret-Frenet formulae; Normal plane; Rectifying plane and oscillating plane.
Course Outcomes (COs):	The students of the course should be able to – CO1: Solve matrix, determinant and related linear algebra problems (K2) CO2: Describe elements of three-dimensional co-ordinate geometry (K1) CO3: Interpret basics of vector algebra and vector calculus (K2) CO4: Apply the rules of vector algebra and vector calculus in complex applied problems (K3)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**	**1**	**1**											
CO2	**3**	**2**	**1**	**1**											
CO3	**3**	**2**	**1**	**1**											
CO4	**3**	**2**	**1**	**1**											

Course Code: ME(M2)/PC/B/EE /T/122	Course Name: Electrical Machines	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: BS	Nature of Course: Theoretical	

Course content/Syllabus:	**Direct current machines**: Operating principle of DC generator and motor, Construction and winding, Ring wound armature, commutator, lap and wave winding, emf equation, armature reaction, Losses in DC machines and efficiency determination by brake, Swinburne and Hopkinson methods. Speed-torque characteristics of DC motors, starting and speed control by rheostats and thyristors. Testing and selection of DC machines (10 lectures) **Single phase transformer:** Principle of operation**,** types of transformers, construction, emf equation**,** equivalent circuits, phasor diagram, losses and efficiency, open circuit and short circuit tests, auto transformer (8 Lectures)
	Three phase circuits: Introduction to 3-phase systems, relationship between line and phase voltages in star connected and delta connected systems, measurement of power in 3-phase systems. Introduction to 3phase transformer. Two-wattmeter method for star connection and delta connection, Three-wattmeter method for 3-phase 4-wire circuit, Energy meter (4 Lectures) **Synchronous machines**: Production of rotating magnetic field; concept of synchronous speed, Synchronous motors and generators (8 Lectures) **Induction machines**: Principle of operation of 3-phase induction machine, Single phase induction motors, slip, Starting and speed control of 3-phase induction motor, Testing (10 Periods)
Course Outcomes (COs):	The students of the course should be able to CO1: Recall the principles of electrical circuits and measurements (K1) CO2: Describe the operating principles of different types of circuits and electrical machines (K2) CO3: Select the types of drives, transformers etc. for specific applications (K3) CO4: Analyse performance, testing and control of electrical machines (K4)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**													
CO2	**3**	**2**													
CO3	**1**	**3**	**2**												
CO4	**2**	**3**	**2**												

Course Code: ME(M2)/PC/B/T/123	Course Name: Strength of Materials	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	

Course content/Syllabus:	Uni-axial stress field inclusive of statically indeterminate systems and thermal stress problems. Relation between engineering constants. Torsion of circular shafts; close-coiled helical springs. Shear force and bending moment diagrams in beams; stresses in beams (bending stress and shear stress); combined bending and twisting. Deflection in beams using different methods. Stresses in thin-walled pressure vessels. Plane stress problems; Mohr's circle for stress. Buckling of columns.
Course Outcomes (COs):	CO1: Solve simple engineering problems under uniaxial, torsional and bending loading. (K2) CO2: Apply the concepts to approach general engineering problems for biaxial stress field. (K2) CO3: Apply the concepts to approach engineering problems related to buckling of columns. (K2) CO4: Define the fundamental material behavior of engineering materials. (K1)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**	**1**												
CO2	**3**	**2**	**1**			**1**								**1**	
CO3	**3**	**2**	**1**			**1**								**1**	
CO4	**3**	**1**	**1**												

Course Code: ME(M2)/ES/B/T/124	Course Name: Fluid Mechanics - I	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: ES	Nature of Course: Theoretical	

Course content/Syllabus:	Definition of fluid, continuum hypothesis, different properties of fluid, classification (like Newtonian/nonNewtonian, ideal/real etc.). (2 hrs.) Fluid Statics: pressure at a point, Pascal's law, variation of pressure within a static fluid – equation of hydrostatic pressure distribution, variation of properties in static atmosphere; measurement of pressure; hydrostatic thrust on plane and curved surfaces; buoyancy, stability of submerged and floating bodies. (5 hrs.) Fluid Kinematics: preliminaries of Eulerian and Lagrangian description of fluid flow; velocity and acceleration of fluid particles in rectilinear and curvilinear co-ordinates; different types of flow – steady and unsteady flow, uniform and non-uniform flow, one- two and three dimensional flow, rotational and irrotational flow, laminar and turbulent flow; stream line, streak line and path line; stream filament and stream tube; principle of conservation of mass – equation of continuity for a stream tube and for unsteady three dimensional flow; deformation of a fluid particle – linear and angular deformation and rotation; vortex motion; relative equilibrium of fluids. (8 hrs.) Fluid Dynamics: principle of conservation of linear momentum, Euler's equation of motion along a stream line and for unsteady three dimensional flow; derivation of Bernoulli's equation and physical significance of different terms; applications of Bernoulli's equation in flow measurement devices: stagnation tube, pitot tube, venturi meter, orifice meter, triangular and rectangular weir. (7 hrs.) Application of Linear Momentum to Control Volume: linear momentum equation; analysis of force exerted by a fluid stream on a solid boundary – jet impingement, thrust on pipe bends etc. (2 hrs.) Principle of Conservation of Angular Momentum and its application. Steady Flow Energy Equation and its application.(2 hrs.) Characteristics of Laminar and Turbulent Flow: Reynolds experiment, critical Reynolds number; laminar flow through pipe – Hagen Poiseuille equation. (3 hrs.)
	Flow Through Closed Conduits: Darcy Weisbach equation, friction factor of closed conduits, flow through noncircular ducts, Moody's diagram and its use; minor losses – at sudden expansion, at sudden contraction, at bends, at valves and fittings etc; analysis of simple pipe network problems. (6 hrs.) Free Surface Flow: flow in open channel, Chezy's equation, Manning's equation, economical cross section, specific energy, hydraulic jump. (5 hrs.)
Course Outcomes (COs):	The students of the course should be able to – CO1: Classify fluids and flows based on properties and kinematic conditions. (K2) CO2: Develop the governing equations for fluids at rest and in motion. (K3) CO3: Solve hydrostatic and flow problems related to simple systems and devices. (K3) CO4: Relate governing equations with the operation of measurement devices. (K4)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**1**													
CO2	**3**	**2**	**1**	**1**											
CO3	**2**	**3**	**2**	**1**	**1**										
CO4	**3**	**2**	**1**												

Course Code: ME(M2)/ES/B/T/125	Course Name: Thermodynamics	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: ES	Nature of Course: Theoretical	

Course content/Syllabus:	Introduction: Microscopic and Macroscopic viewpoints in thermodynamics. Fundamental concepts of System, Control volume, State, Property, Equilibrium, Processes. Etc. 2 Hours The Zeroth law of thermodynamics: Thermal equilibrium. Temperature. Principle of thermometry. International practical temperature scale. 2 Hours Energy: Different energy forms-stored energy, energies in transition (Heat& Work). Definitions. 2 Hours Properties of pure substances: Thermodynamics' properties of pure substances in solid, liquid and vapour phases. P-V-T behaviour of simple compressible substances. Phase rule. State postulate. Thermodynamic property tables and charts. Ideal and Real gascs. Equations of state. Compressibility factor. Generalised compressibility chart. Problems. 8 Hours The First law of thermodynamics: The first law of thermodynamics for systems. Corollaries. Internal energy and enthalpy. First law for control volumes. Steady state and unsteady state applications, Process calculations for ideal and real gases using equations, tables and charts. Problems. 6 Hours The Second law of thermodynamics: Limitations of the first law of thermodynamics. Steadily operating systems-Heat engine, Heat Pump and refrigerator. Introduction to power and refrigeration cycles. Thermal efficiency. Coefficient of Performance. Carnot cycle. Statements of the second law of thermodynamics. Equivalence of Kelvin Planck and Clausius statements of the second law of thermodynamics. Corollaries. Entropy. Reversibility and Irreversibility. Problems. Mollier Chart and its use. Second law analysis of control volume. Entropy generation. Reversible work. Availability. Irreversibility. 10 Hours Thermodynamic relationships: Tds relations. Maxwell equations. Clapeyron equation, Clausius Clapeyron equation. Joule-Thompson coefficient. Compressibility and expansion coefficient. Problems. Development of property data in graphical and tabular form. 4 Hours Basic Thermodynamic Cycles: Power cycles (Gas and vapor) and Refrigeration cycles. 5 Hours
Course Outcomes (COs):	The students of the course should be able to CO1: Define thermodynamic system and related terminologies (K1) CO2: Interpret the fundamental laws and principles (K2) CO3: Apply laws and principles of thermodynamics for simple engineering systems (K3) CO4: Analyse thermodynamic systems (K4)
CO-PO Mapping:	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**						**1**								
CO2	**3**	**2**													
CO3	**2**	**3**	**1**											**1**	
CO4	**1**	**3**	**1**	**1**										**1**	

Course Code: ME(M2)/ES/B/S/121	Course Name: Descriptive Geometry and Surface Development	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: ES	Nature of Course: Sessional	

Course content/Syllabus:	Introduction to the concept of Descriptive Geometry: points, lines, surfaces and their classifications. Projection of points and lines, and their projections on principal and auxiliary planes. Relation of the coordinate axes and the planes of projections. Methods of finding true shape of different lines and different surfaces. (3 hours) Revolution method & Auxiliary view method of finding the true shape of different types of lines. (3 hours) Determining the true shape of a plane. (3 hours) Determination of the Relations (perpendicular distance, foot of perpendicular, angle, line of intersection etc.) among point, line and plane. (3 hours)
	Intersection of a line with curved surfaces: a cylinder, cone and sphere, (3 hours) Concept and definition of Trace of points and lines, Trace of different types of lines: (3 hours) Traces of planes. To determine the line of intersection and the angle between the edge views of two planes by the method of trace. (6 hours) Surface Development of simple objects (both right angled and oblique): cylinders, prisms, pyramids and cones. (6 hours) Surface development of objects cutting each other, Intersection of different surfaces. (6 hours) Surface development of objects for transition of shapes with maximum utilization of surface. (6 hours)

Course Outcomes (COs):	Students of the course should be able to CO1: Illustrate the projection of points, lines and planes on principal and auxiliary planes following the concept of engineering drawing. (K2, A2, S3) CO2: Demonstrate different methods to determine true lengths of lines and true shapes of planes. (K3, S3) CO3: Determine the relations among point, line and planes combining the knowledge of true length and true shape. (K4, S4) CO4: Show the traces of lines and planes. (K3, S3, A2) CO5: Develop surfaces of different objects such as simple objects, intersection of different surfaces, transition pieces with maximum utilization of surface, etc. (K3, S4, A4)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1									1		2		
CO2	2	1									1		3		
CO3	3	2									1		2		
CO4	3	1									1		2		
CO5	2	2	1								1		3	2	

Course Code: ME(M2)/ES/B/S/122	Course Name: Computer Programming	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: ES	Nature of Course: Sessional	

Course content/Syllabus:	Introduction: History of Computing, Evolution of Programming Languages, Compilers, Interpreter Algorithms and Flowcharts, Structure of a C Program [3□3 h] Expressions: Basic Data Types, Variables, Type Qualifiers, Variable Scopes, Constants, Assignment Statements, Operators, Operator Precedence, Expression Evaluation, Type Conversion in Expressions, Type Casting; Console I/O: Reading and Writing different data types [2□3 h] Control Statements: Selection Statements (if, switch-case), Loop Statements (*for, while, do-while*), Jump Statements (return, goto, break, exit, continue) [2□3 h] Arrays and Strings: Single Dimension Arrays, Double Dimension Arrays, Strings [2□3 h] Functions: General Form, Function Prototypes, Introduction to Pointer variables, Parameter Passing Mechanisms, Command Line Arguments [2□3 h] File I/O: Introduction to File, File reading and writing [1□3 h] Structures, Unions: Structures, Arrays of Structures, Unions [1□3 h]
Course Outcomes (COs):	The students of the course should be able to – CO1: Describe the various parts and organization of hardware and software components of modern digital computers. CO2: Construct flowcharts for simple problems. CO3: Acquire fundamental concepts about high level programming languages. CO4: Use general programming principles to build codes to solve simple problems

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3				1								2		
CO2	3	2	1										1		
CO3	3	2			3				1				1		
CO4	2	2	2		3				2				2		

Course Code: ME(M2)/ES/B/S/123	Course Name: Workshop Practice - II	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: ES	Nature of Course: Sessional	

Course content/Syllabus:	Introduction to fitter’s tools, gauges, measuring instruments etc.; marking of jobs; fitter’s job involving chipping, filing, sawing, drilling; use of taps and dies; pipe fittings and plumbing. Introduction to and practice of different welding processes- gas, SMAW, TIG, MIG, SAW, resistance welding etc.; introduction to gas cutting and its application; soldering, brazing etc.; making welded joints using different welding processes.

Course Outcomes (COs):	The students of the course should be able to – CO1: Recognise the tools and techniques of fitting and welding (K2, A1) CO2: Translate basic concepts of fitting for replicating simple engineering component (K2, S1) CO3: Translate basic concepts of arc welding for joining simple engineering components (K2, S2)
	CO4: Describe different commonly used methods of welding and their applicability (K2, A1) CO5: Recognise some sources of welding defects and remedies to overcome them. (K2, A1)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**								**2**		**1**				
CO2	**3**	**1**						**2**	**2**				**2**	**1**	
CO3	**3**	**1**						**2**	**2**				**2**	**1**	
CO4	**3**						**2**		**1**						
CO5	**3**	**2**				**1**			**1**		**1**				

Course Code: ME(M2)/ES/B/EE&ET/S/124	Course Name: Electrical Technology Lab	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: ES	Nature of Course: Sessional	

Course content/Syllabus:	Recalibration of ammeter and voltmeter Measurement of Resistance of various electrical equipment Behavior of R-L, R-C and R-L-C circuit with AC and DC supply Characteristics of AC series & parallel Circuit Power & Power factor characteristics of Fluorescent Lamp Voltage and power characteristics of a ceiling fan Verification of Thevenin's Theorem & Maximum Power Transfer Theorem Study of DC and AC Machines Coil connections & ratings of single phase transformer Introduction, arrear and assignment
Course Outcomes (COs):	The students of the course should be able to – CO1: Identify the instruments required to perform the experiment (K1, S1) CO2: Select the range/ratings of the instruments identified (K2, S1) CO3: Comprehend the objective of the experiment and Relate that with the acquired theoretical knowledge (K3, S2) CO4: Develop the circuit duly connecting selected instruments and other devices (K2, S2) CO5: Interpret the data and prepare a detailed report. (K2, S2)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**	**1**						**2**				**3**		
CO2	**1**	**3**	**2**						**2**				**3**		
CO3	**1**	**3**	**2**						**2**				**2**		
CO4	**1**	**2**	**3**						**2**				**3**	**2**	
CO5	**1**	**1**	**2**	**3**				**1**	**2**		**1**	**1**	**2**		

Course Code: MC/TS/P101	Course Name: Technical Communicative English & Soft Skill	
Credits: 0	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 0
Category of Course: MC	Nature of Course: Sessional	

Course content/Syllabus:	**I. UNDERSTANDING COMMUNICATION** Meaning of Communication The Communication Process/Basic Elements of Communication (Sender, Message, Receiver, Channel) Purpose/Importance of Communication Channels of Communication (Upward, Downward, Horizontal/Lateral, Diagonal/Spiral) Different Forms of Communication (Verbal and Non-verbal, Interpersonal, Intrapersonal, Extrapersonal) Barriers to Effective Communication and their Possible Remedies **II. SPOKEN COMMUNICATION** Non-verbal Communication (Body Language, Paralinguistic features, Proxemics/Space Distance, Haptics) Dynamics of Professional Presentations (Individual and Group) Group Discussions Job Interviews **III. LISTENING SKILLS** Types of Listening Implications of Effective Listening Barriers to Effective Listening Effective Listening Strategies **IV. WRITTEN COMMUNICATION** The Art of Condensation – Steps to Effective Precis Writing Job Application Letters and Resumes Writing a Report Writing a Technical Proposal Planning business messages (Email, Memo, Notice, Agenda, Minutes, Circulars)
Course Outcomes (COs):	The students of the course should be able to CO1: Comply basic form of communication through development of positive personal attitude. (A2)
	CO2: Present effectively in group discussions and mock interviews. (A2) CO3: Recreate reports in different forms like first draft, final draft, planning business messages. (S2) CO4: Show proficiency in oral presentation through motivational speeches, effective presentation skills and positive body-languages. (A2, S3) CO5: Respond to discussion through effective listening. (A2)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						**1**			**2**	**3**		**2**			**1**
CO2									**2**	**3**	**2**	**2**			**2**
CO3						**1**	**1**		**2**	**3**	**2**	**2**	**2**		**2**
CO4									**2**	**3**	**2**	**2**			**3**
CO5									**2**	**3**	**2**	**3**			**2**

2nd Year 1st Semester

Course Code: ME(M2)/BS/B/MATH/T/211	Course Name: Mathematics III	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: BS	Nature of Course: Theoretical	

Course content/Syllabus:	Advanced Linear Algebra (Marks: 50) Vector space, subspace, Basis and Dimension; Linear transformation; Representation of linear transformation by matrices; Linear functional; Dual space; Transpose of a linear transformation; Diagonalization, Symmetric and orthogonal matrices, Invariant subspaces; Cyclic subspaces; Annihilators; Cyclic decomposition; Rational form; Jordan canonical form; Inner product spaces; Gram-Schmidt orghogonalization; Adjoints of linear operators; Unitary and Normal operators. Ordinary Differential Equation (ODE) and Series Solution: (Marks:30) First order exact differential equation and first order linear differential equation; Second and higher order linear differential equations with constant coefficients; Euler and Cauchy equation; Method of variation of parameters; Ordinary point and regular singularity of a second order linear differential equation; Series solutions; Solution of legendre and Bessel's equations; Generating functions; Recurrence relations and their Orthogonal properties Partial Differential Equation (PDE): (Marks:20) First order PDE; Lagrange method; Second order PDE with constant coefficients and their classifications to Elliptic, Parabolic and Hyperbolic type. Solution of PDE by method of separation of variables; Solution of one dimensional wave and diffusion equation; Laplace equation of two dimensions.
Course Outcomes (COs):	The students of the course should be able to – CO1: Define vector space and its associated concepts CO2: Solve various linear algebra transformations, diagonalization, Gram-Schmidt orthogonalization problems CO3: Solve complex linear algebra problems CO4: Develop solutions of differential equations associated to complex systems CO5: Construct a PDE for a given physical problem CO6: Solve partial differential equations associated with complex systems

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**	**1**												
CO2	**3**	**2**	**1**												
CO3	**3**	**2**	**1**												
CO4	**3**	**2**	**1**												
CO5	**3**	**2**	**1**												
CO6	**3**	**2**	**1**												

Course Code: ME(M2)/PC/B/T/212	Course Name: Engineering Dynamics	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	
Course content/Syllabus:	Kinematics of particle, rectilinear motion of a particle, plane curvilinear motion of a particle in different coordinate systems, constrained motion of connected particles. Kinetics of particle, application of Newton's Law for rectilinear and two-dimensional motion of a particle in different coordinate systems, principles of work-energy and impulse-momentum in particle dynamics. Impact of particles. Central force motion. Introduction to the dynamics of the systems of particles. Kinematics of the plane motion of a rigid body using various methods. Equations of plane motion of rigid bodies in various forms. Principles of work-energy and impulse-momentum for the plane motion of a rigid body.	
Course Outcomes (COs):	The students of the course should be able to CO1: Remember the principles of kinematics of particle (rectilinear and curvilinear motion). (K1) CO2: Explain the principles of plane kinetics of particle using Newton's law, work-energy and impulsemomentum principles. (K2)	
	CO3: Understand the principles of kinematics of rigid bodies in two dimensions. (K2) CO4: Solve problems related to rigid body plane dynamics. (K3)	

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**1**										**1**			
CO2	**3**	**2**													
CO3	**3**	**2**													
CO4	**3**	**2**	**3**	**1**										**1**	

Course Code: ME(M2)/PC/B/T/213	Course Name: Fluid Mechanics - II	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100

Category of Course: PC	Nature of Course: Theoretical
Course content/Syllabus:	Basic concept of turbulence and turbulent flow. (1 hrs.) Equation of motion for viscous flow – 2D laminar flow between flat parallel plates & annulus (2 hrs.) Boundary Layer Theory: concept of boundary layer, boundary layer thickness, displacement thickness, momentum thickness, growth of boundary layer; Prandtl's boundary layer equations, Von Karman's momentum integral equation for a boundary layer, skin friction drag coefficient for laminar and turbulent boundary layer, hydraulically smooth and rough surfaces; boundary layer in pipe flow, friction velocity; separation of boundary layer, form drag, method of drag reduction; lift and drag on submerged bodies, aerofoils, stalling of aerofoils.(10 hrs.) Compressible Flow: review of thermodynamic principles for perfect gases, adiabatic and isentropic relations; steady flow energy equation; speed of propagation of a small disturbance through a compressible fluid, sonic velocity, Mach number, Mach cone and Mach wave; isentropic flow, stagnation properties of a compressible flow, isentropic pressure, temperature and density ratios; compressibility correction factor in the measurement of air speed; area – velocity relationship for compressible flow through a variable area duct, mass flow rate through a duct, critical condition and choking; flow through convergent-divergent nozzle, over expansion and under expansion, performance of propulsive nozzles; normal shock, normal shock relations, wave drag.(10 hrs.) Ideal Fluid Flow: rotation of a fluid particle, vorticity, rotational and irrotational motion; velocity potential function, circulation, stream function, flownet; governing equation for two dimensional irrotational motion, simple two dimensional irrotational flows like uniform flow, plane source, plane sink etc; superimposition of simple irrotational flows, combination of a source and a sink, combination of uniform flow and a source(Rankine half body), combination of a uniform flow and a source-sink pair (Rankine oval), doublet and its strength, superimposition of an uniform flow and a doublet (flow past a stationary cylinder); vortex motion –free and forced vortex, strength of a vortex; combination of a uniform flow, a doublet and a free vortex (flow over a rotating cylinder), Magnus effect, Kutta-Joukowski's theorem.(12 hrs.) Dimensional analysis and Buckingham Pi theorem; similarity and model studies. (3 hrs.) Unsteady flow – water hammer.
Course Outcomes (COs):	The students of the course should be able to CO1: Describe boundary layer flow, turbulent flow, compressible flow, ideal flow and unsteady flow. (K2) CO2: Develop the governing equations for different types of flow. (K3) CO3: Analyse different flow models with practical implications. (K4) CO4: Solve problems for different types of flows. (K3)
CO-PO Mapping:	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**	**1**												
CO2	**3**	**2**	**1**	**1**											
CO3	**2**	**3**	**1**	**1**											
CO4	**2**	**3**	**2**	**1**	**1**										

Course Code: ME(M2)/PC/B/T/214	Course Name: Heat Transfer	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	
Course content/Syllabus:	Introduction: Modes of heat transfer. Conduction: Fourier law of heat conduction for isotropic material. Thermal conductivity. Derivation of general heat conduction equation. Non- dimensionalisation - thermal diffusivity and Fourier number. Types of boundary conditions. Solution of steady one dimensional conduction problem with and without heat generation. Analogy with electrical circuits. Critical thickness of insulation. Fins-rectangular and pin fins. Fin effectiveness and efficiency. Lumped parameter approach and significance of time constant. Biot number. Solution of 1-D transient heat conduction equation without generation using product solution. 10 Hours Radiation: Physical mechanism of thermal radiation. Laws of radiation. Definition of black body, emissive power. Radiation intensity. Reflectivity. Transmissivity. Irradiation, radiosity. Radiation view factor and its properties. Radiation exchange between black bodies Concept of grey-diffuse-isotropic surface. Exchange between GDI surfaces by radiation network method. Radiation shielding. 8Hours	

	Convection: Introduction. Newton's law of cooling and significance of heat transfer coefficient. Momentum and energy equation in two-dimensions. Non-dimensionalisation and significance of nondimensional quantities. Scale analysis for flow over flat-plate. Velocity and thermal boundary layer thickness by integral method. Natural convection-effect of coupling on the conservation equation. One dimensional solution for Couette and Poiseuille flow. Concept of developing and developed flow. Correlations-forced convection for external and internal flows. Natural convection over a vertical flatplate. 15 Hours Heat exchangers: Types of heat exchangers. Introduction to LMTD and its correction factor. Fouling factor, effectiveness-NTU method for heat exchangers, rating and sizing. 4 Hours
Course Outcomes (COs):	The students of the course should be able to CO1: Understand the fundamental laws and mechanisms governing various heat transfer modes. (K2) CO2: Develop methodologies for analyzing different modes of heat transfer. (K3) CO3: Formulate problems associated to different modes heat transfer. (K5) CO4: Solve simple practical problems of steady and unsteady state heat transfer. (K3) CO5: Analyze sizing and rating problems associated with different types of heat exchanger. (K4)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**					**1**								
CO2	**3**	**2**	**2**												
CO3	**2**	**3**	**1**	**1**										**2**	
CO4	**2**	**3**	**2**		**1**										
CO5	**3**	**3**	**2**											**2**	

Course Code: ME(M2)/PC/B/T/215	Course Name: Material Science and Engineering	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	

Course content/Syllabus:	**Structure:** Crystal structure of materials, crystal systems, unit cells and space lattices, miller indices of planes and directions, packing geometry in metallic, ionic and covalent solids. Imperfections in crystalline solids and their role in influencing various properties. **Diffusion:** Fick's laws and application of diffusion in sintering, doping of semiconductors and surface hardening of metals. **Mechanical Properties:** stress-strain diagrams of metallic, modulus of elasticity, yield strength, tensile strength, toughness, elongation, plastic deformation, viscoelasticity, hardness, impact strength, creep, fatigue, ductile and brittle fracture. **Electronic Properties:** Concept of energy band diagram for materials – conductors, semiconductors and insulators, electrical conductivity effect of temperature on conductivity, intrinsic and extrinsic semiconductors, dielectric properties. **Metals and Alloys:** Solid solutions, solubility limit, phase rule, binary phase diagrams, intermediate phases, intermetallic compounds, iron-iron carbide phase diagram, heat treatment of steels; cold and hot working of metals; recovery, recrystallization and grain growth; microstrcture, properties and applications of ferrous and non-ferrous alloys. **Ceramics:** Structure, properties, processing and applications of traditional and advanced ceramics. **Polymers:** Classification, polymerization, structure and properties, additives for polymer products, processing and applications. **Composites:** Powder Metallurgy; Properties and applications of various composites. **Introduction to Advanced Materials and Tools:** Smart materials, exhibiting ferroelectric, piezoelectric, optoelectric, nanomaterials, synthesis, properties and applications, biomaterials, superalloys, shape memory alloys. Materials characterization techniques. **Environmental Degradation:** Corrosion and oxidation of materials, prevention.

Course Outcomes (COs):	The students of the course should be able to CO1: Identify materials and material processing technologies used for different engineering applications. (K2) CO2: Interpret the various structures and properties of materials, material characterization techniques. (K2) CO3: Solve numerical problems related to materials, properties and processes. (K3) CO4: Analyze various structures of materials to investigate the structure –property correlation for various engineering applications. (K4) CO5: Identify mechanisms of material degradation and techniques for prevention of degradation. (K2)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3				1										
CO2	3				2										
CO3	2	3			1								2		
CO4	3	2	1		2										
CO5	3					1	2								

Course Code: ME(M2)/PC/B/S/211	Course Name: Computer Aided Drafting	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: PC	Nature of Course: Sessional	

Course content/Syllabus:	Introduction to a computer aided drafting software, Basic commands of 2D drafting, Drafting assignment (9 hours). Concept of Layer, Layout, Model space, Paper space, Viewport, Creation and use of template, Drafting assignment (12 hours). Dimensioning, Blocks, Attributes, Accessing internal and external database files, Drafting assignments (12 hours). Isometric drawing using iso-planes, Drafting assignment (9 hours).
Course Outcomes (COs):	The students of the course should be able to – CO1: Identify the basic 2D drafting tools (drawing and editing) and toolbars in drafting software. (K1, A1, S1) CO2: Interpret the concept of layer, and of model space and paper space in conjunction with viewport. (K2, A2, S2) CO3: Describe the concept of blocks, attributes etc. to better organize complicated drawings. (K2, A2, S2) CO4: Prepare engineering drawing of simple machine components up to its paper printout with proper scale. (K3, A3, S3) CO5: Construct isometric drawings for simple engineering components. (K3, A2, S2)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1			1		3	1		1	2	1			2		
CO2			1		3	1		1	2	1			2		
CO3			1		3			1	1	1			1		
CO4	2		2		3	1		1	2	2			2		
CO5	2		1		3	1		1	2	2			2		

Course Code: ME(M2)/PC/B/S/212	Course Name: Machine Drawing – I (Drawing Board Mode)	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: PC	Nature of Course: Sessional	

Course content/Syllabus:	Screw threads, Screwed fastenings - Nuts, Bolts, Set screws, Foundation bolts etc. (2x3 hours) Rivetted joints and welded joints (2x3 hours) Keys, Cotter joint/ Knuckle joint/ Pipe joints (2x3 hours) Pulleys (2x3 hours) Shaft coupling: Rigid/ Flanged/ Flexible (2x3hours) Stuffing box (2x3hours)

Course Outcomes (COs):	The students of the course should be able to CO1: Describe the functions, uses and appropriate materials of different machine elements. (K2) CO2: Apply the knowledge of engineering drawing for machine drawing. (K3) CO3: Develop detailed drawing of machine components. (A4, S4) CO4: Develop assembly drawing of machine components. (A4, S4)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**										**1**				
CO2	**3**	**1**	**1**								**1**				
CO3	**3**	**1**	**2**							**1**	**1**		**2**	**1**	
CO4	**3**	**1**	**2**							**1**	**1**		**2**	**1**	

Course Code: ME(M2)/PC/B/S/213	Course Name: Electrical Technology Lab. (- II)	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: PC	Nature of Course: Sessional	

Course content/Syllabus:	Determination of phase sequence of a three phase AC supply Study of different characteristics of a DC Generator Parallel operation of single phase transformers Study of load performance of DC Series Motor Starting and speed control of a DC Shunt Motor Synchronization and V-curve of Synchronous Machine Open Circuit & Short Circuit characteristics of a single Phase transformer Study of motor control elements Determination of parameters of a 3-phase slip ring induction motor Load characteristics of 3-phase Induction motor Introduction, arrear and assignment
Course Outcomes (COs):	The students of the course should be able to – CO1: Identify the instruments required to perform the experiment (K1, S1) CO2: Select the range/ratings of the instruments identified (K2, S1) CO3: Comprehend the objective of the experiment and Relate that with the acquired theoretical knowledge (K3, S2) CO4: Develop the circuit duly connecting selected instruments and other devices (K2, S2) CO5: Interpret the data and prepare a detailed report. (K2, S2)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**	**1**						**2**				**3**		
CO2	**1**	**3**	**2**						**2**				**3**		
CO3	**1**	**3**	**2**						**2**				**2**		
CO4	**1**	**2**	**3**						**2**				**3**	**2**	
CO5	**1**	**1**	**2**	**3**				**1**	**2**		**1**	**1**	**2**		

Course Code: ME(M2)/BS/B/S/214	Course Name: Numerical Analysis	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: BS	Nature of Course: Sessional	

Course content/Syllabus:	Numerical Analysis and its implementation through computer programming: Approximations and Errors associated with numerical methods. [1□3 h] Solution of non-linear equations: Bisection method, Newton-Raphson method. [2□3 h] Solution of linear simultaneous equations: *Direct methods:* Gauss-Jordan elimination, matrix inversion using Gauss-Jordan elimination [2□3 h] *Iterative methods:* Jacobi's method [1□3 h] Methods for interpolation: Newton's forward difference formula, Newton's backward difference formula, Lagrange's formula. [2□3 h] Curve fitting: Method of least squared error [1□3 h] Methods for differentiation and Integration: Computation of derivatives using Newton's forward/backward/central difference formulae. Trapezoidal method, Simpson's method. [2□3 h] Solution of differential equations: Euler's method, modified Euler's method, Runge-Kutta 2nd and 4th order formulae [2□3 h]
Course Outcomes (COs):	CO1: Solve algebraic equations numerically. CO2: Solve differentiation, integration and differential equations numerically. CO3: Solve interpolation and regression problems numerically with applications. CO4: Develop computer programs for numerical methods.
CO-PO Mapping:	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**	**2**												
CO2	**3**	**2**	**2**												
CO3	**3**	**2**	**2**											**1**	
CO4	**2**	**2**	**2**		**3**				**2**			**1**	**3**	**1**	

2nd Year 2nd Semester

Course Code: ME(M2)/BS/B/MATH/T/221	Course Name: Mathematics - IV	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: BS	Nature of Course: Theoretical	

Course content/Syllabus:	Probability and Statistics (Marks : 50) Definition of probability; Conditional probability and independence; Bayes' theorem; Statistical data: mean, median, mode, standard deviation; Random variables; Discrete and Continuous distribution; Poisson, Normal and Binomial distribution; Correlation and Regression; Expectation and Variance; Chebysheff's inequality. Fourier series and Integral Transforms: (Marks:50) Fourier series; Periodic functions; Trigonometric series of sine and cosines; Euler's formula; Even and odd functions; Dirichlet's conditions; Half range sine and cosine series; Fourier transform, definitions and properties; Inverse Fourier transform; Convolution; Laplace transform, properties; Inverse Laplace transform; Convolution; Z transform and properties.
Course Outcomes (COs):	The students of the course should be able to – CO1: Define probability, conditional probability, independence of events CO2: Comprehend Bayes' theorem and probability distribution functions
	CO3: Explain correlation-regression, mathematical expectation and variance CO4: Discuss Fourier series and its related topics CO5: Describe Laplace transforms, inverse Laplace transform, Z-transforms and their various properties
CO-PO Mapping:	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**	**1**												
CO2	**3**	**2**	**1**												
CO3	**3**	**2**	**1**												

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO4	**3**	**2**	**1**												
CO5	**3**	**2**	**1**												

Course Code: ME(M2)/PC/B/T/222	Course Name: Fluid Machinery - I	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	
Course content/Syllabus:	Introduction: Definition, Classification and Application. (1 hr) Turbomachines: Classification and Constructional Features: Incompressible and compressible flow machines, Pump, Turbines and Compressor. Radial, axial and mixed flow type machines; Impulse and reaction turbines; Impeller, volute casing, diffuser, runner and inlet guide vane. Principles of Energy Transfer, Euler one dimensional pump and turbine equations, Euler head, Bernoulli equation, Rotor work and efficiency for incompressible flow turbomachines, Velocity diagrams for radial and axial flow machines, Blade twist. Different heads and efficiencies for pumps, fans and turbines. (25 hrs.) Special Devices: Analysis of flow through propellers and windmills, Slipstream and actuator disc theory; Jet propulsion devices, Analysis of thrust and other performance parameters; Jet pump. (5 hrs.) Positive Displacement Pumps: Reciprocating and rotary Pumps, Working principle and indicator diagram for reciprocating pump, Air vessel. (9 hrs.)	
Course Outcomes (COs):	The students of the course should be able to- CO1: Classify different types of fluid machines. (K2) CO2: Explain the operations of fluid machines and associated devices. (K2) CO3: Develop equations for discharge/velocity and head/pressure from first principles. (K3) CO4: Apply the basic equations and energy concepts for solving problems related to fluid machines. (K3)	
CO-PO Mapping:		

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**1**													
CO2	**3**	**1**													
CO3	**2**	**3**	**1**												
CO4	**2**	**3**	**2**												

Course Code: ME(M2)/PC/B/T/223	Course Name: Advanced Engineering Mechanics	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	
Course content/Syllabus:	Strain Analysis of plane strain condition, Mohr's circle for plane strain, strain rosette. Statically indeterminate beams. Energy methods; Castigliano's theorems. Kinematics of rigid bodies in three dimension; Euler's angles. Mass moment of inertia of rigid bodies and its properties; three-dimensional kinetics of rigid bodies in various forms; Euler's equations of motion; gyroscopic effect. Energy method in three-dimensional kinetics of rigid bodies.	
Course Outcomes (COs):	The students of the course should be able to- CO1: Explain the concepts of plane strain condition using Mohr’s circle. (K2) CO2: Comprehend energy method and Castigliano’s theorem. (K2) CO3: Understand angular position specification of a rigid body using Euler's angles. (K2) CO4: Apply the principle of mechanics to solve three dimensional kinematics of rigid bodies. (K3) CO5: Analyze the three-dimensional kinetics of rigid bodies in various forms. (K4)	
CO-PO Mapping:		

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**1**													
CO2	**3**	**2**													
CO3	**3**														
CO4	**3**	**3**	**3**	**2**										**2**	
CO5	**3**	**3**	**2**	**1**										**2**	

Course Code: ME(M2)/PC/B/T/224	Course Name: Kinematic Analysis and Synthesis	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	
Course content/Syllabus:	Introduction to kinematics of machines, mechanism and structure, kinematic pairs; sis; 4-bar linkage mechanism, kinematic inversion and Grashof’s criteria, degree of freedom. (6 pds)	

	Analysis of planar kinematic devices: Velocity analysis of linkages (graphical methods: resolution and composition, instantaneous axis and relative velocity) Acceleration analysis of linkages (graphical and analytical methods), Kennedy’s theorem. (10 pds) Linkage: drag link mechanism, automobile steering mechanism, slider-crank mechanism, swinging block mechanism, oscillating arm quick return mechanism, isosceles linkage, elliptic trammel, toggle mechanism, straight line mechanism, pantograph, universal joint, etc. Geneva wheel mechanism, intermittent motion from continuous motion. (4 pds) Gears: Fundamental laws of gearing, types of gears - involute and cycloidal; spur, helical, bevel and worm gears; rack and pinion, gear nomenclature, interference and undercutting - minimum number of teeth, backlash, velocity of sliding. Gear trains: simple, epicyclical, epicyclical bevel gear trains, train value; applications: automobile transmission and others. (10 pds) Cam drive: plate and cylindrical, inline and offset – displacement, velocity and acceleration diagram, different cam displacement functions and cam profiles, analytical approach to design of different types of cams. (6 pds) Syntheses: movability of linkages – Grubler’s criterion, type and number syntheses, minimum number of binary linkages in a constrained mechanism, maximum number of hinges on a link, graphical and analytical methods of syntheses, (Freudenstein equation, Chebysev spacing, approximate syntheses. (6 pds)
Course Outcomes (COs):	The students of the course should be able to- CO1: Describe various types of mechanisms and linkages along with different kinematic parameters (K2) CO2: Compute analytically kinematic parameters associated with planar kinematic mechanisms and devices (K3) CO3: Construct graphically displacement, velocity and acceleration diagrams for planar kinematic mechanisms and devices (K3) CO4: Explain the fundamental laws, working principles, applications and kinematic design aspects of various mechanisms and drives (K2) CO5: Apply kinematic principles to synthesize mechanisms by graphical and analytical methods (K3)

CO-PO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**														
CO2	**2**	**3**	**1**											**1**	
CO3	**2**	**3**	**1**										**1**	**1**	
CO4	**3**	**1**													
CO5	**3**	**2**	**3**	**1**									**2**	**1**	

Course Code: ME(M2)/PC/B/T/225	Course Name: Design of Machine Elements - I	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	

Course content/Syllabus:	Introduction to design, Design philosophy (2 pds) Basic Design Considerations (3 pds) Review of common engineering materials for their compositions, properties and applications including heat treatment and alloying for improvement of properties. (5 pds) Review of stress analysis for static loading- axial, bending, torsion loads and combined effect, stress concentration, Factor of safety (3pds) Theories of failure for static loading (3 pds) Case Studies: Design of mechanical joints (cotter joint / knuckle joint/ universal joint). (4 pds) Manufacturing aspects of design – Manufacturing processes (casting, forming, machining, welding etc.) Fits and tolerance, surface roughness (3 pds) Design of shaft including ASME Code (2 pds) Design for Stability - Buckling analysis (2 pds) Design for fatigue loading- S-N curve, Design for finite and infinite life considering effect of mean stress, Cumulative fatigue damage, Strain life equation for LCF and HCF, Case studies. (10 pds) Application of concept of fracture and creep in design (05 pds)

Course Outcomes (COs):	The students of the course should be able to- CO1: Discuss design philosophies, methodologies and basic design considerations (K2) CO2: Describe properties and compositions of common engineering materials (K2) CO3: Apply theories of failure and concept of factor of safety to solve design problems of simple mechanical components and joints based on stress analysis (K3) CO4: Solve shaft design problems based on static design principles and Codes (K3) CO5: Apply fatigue failure theories for simple and complex design problems (K3) CO6: Recognize the role of practical aspects of manufacturing, stability, fracture and creep in real-life design (K2)
CO-PO Mapping:	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**		**1**			**1**	**1**	**1**							
CO2	**3**	**2**	**1**												
CO3	**3**	**2**	**1**												
CO4	**3**	**2**	**1**					**2**						**1**	
CO5	**3**	**2**	**2**	**1**										**1**	
CO6	**3**		**1**												

Course Code: ME(M2)/PC/B/T/226	Course Name: Manufacturing Processes	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	
Course content/Syllabus:	1. Introduction to Manufacturing Process 2. Foundry Practice: the basic idea, patterns, moulding materials- properties and mould making; various casting processes; core, core print and chaplets, gating system and riser; metal melting furnaces; special casting processes; casting defects, inspection and repair. 3. Forming: hot and cold working of metals; rolling; forging and forging dies; dies; drawing, deep drawing; extrusion; bending; coining, hubbing, embossing, thread rolling, tube piercing etc.; press working etc.; Defects in metal working. 4. Welding and joining processes: classifications; gas welding; flame cutting; electric arc welding-theory of heat generation, power source selection, arc structure, arc characteristic etc.; metal transfer in arc welding; different arc welding process- SMAW, Carbon Arc Welding, Atomic Hydrogen Welding, MIG, TIG, CO2 –MIG, FCAW, other welding processes like ESW, EBW, PAW, USW, Explosion Welding, Friction stir welding etc.; welding consumables; characteristics of weldments; welding defects and inspection; welding of non-traditional welding materials; Introduction to newer processes of welding; soldering and brazing; electric resistance welding- different types. 5. Additive manufacturing: basic concept of rapid prototyping 'rp' processes – like stereo lithography, SLS, FDM, LOM; applications; part deposition planning etc	
Course Outcomes (COs):	The students of the course should be able to – CO1: Identify conventional and modern manufacturing processes and their capabilities. (K2) CO2: Categorize processes according to process parameters. (K4) CO3: Describe different practical aspects of manufacturing processes. (K2) CO4: Analyze real life problems with reference to theoretical concepts. (K4)	
CO-PO Mapping:		

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**													
CO2		**3**													
CO3		**2**	**3**												
CO4	**2**	**3**		**1**											

Course Code: ME(M2)/PC/B/S/221	Course Name: Machine Drawing - II (Computer terminal Mode)	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: PC	Nature of Course: Sessional	
Course content/Syllabus:	Tool head of a shaping machine (2x3 hours) Engine parts: Eccentric, Piston, Cross head and Connecting rod (5x3 hours) Plummer block (2x3 hours) Valves: Steam stop valve, Anyone of safety, relief and non-return valves (5x3 hours)	

Course Outcomes (COs):	The students of the course will be able to: CO1: Describe the functions, uses and appropriate material of various machine components. (K2). CO2: Apply the knowledge of engineering drawing using drafting software. (K3) CO3: Construct detailed part drawings of various machine components using drafting software. (K5, S4) CO4: Develop assembly drawings of various machine components using drafting software. (K5, S4)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**													**1**	
CO2	**3**	**2**			**3**							**2**	**1**		
CO3	**3**	**3**	**2**		**3**				**1**				**2**	**3**	
CO4	**3**	**3**	**2**	**1**	**3**				**1**				**2**	**3**	

Course Code: ME(M2)/PC/B/S/222	Course Name: Fluid Mechanics Laboratory	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: ES	Nature of Course: Sessional	
Course content/Syllabus:	Exp.1. Reynolds Experiment [Laminar/Turbulent] and Determination of Friction Factor Exp.2. Calibration of V-Notch Exp.3. Calibration of Orificemeter and Rotameter Exp.4. Stokes Law Exp.5 Metacentric Height Exp.6. Axisymmetric Jet	
Course Outcomes (COs):	The students of the course will be able to: CO1: Extract primary variables from measurements. (A4) CO2: Estimate different flow parameters and non-dimensional numbers and their relations. (K2)	
	CO3: Verify different laws of fluid mechanics through experiments. (A5) CO4: Characterize different types of flow through visualization and measurement. (A5) CO5: Calibrate flow and pressure measurement devices. (S3) CO6: Prepare experimental reports. (K3)	

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**1**	**3**	**1**						**2**	**1**			**1**		
CO2	**3**	**2**							**2**				**1**		
CO3	**3**	**2**							**2**				**1**		
CO4	**2**	**3**	**1**						**2**	**1**			**1**		
CO5	**2**	**3**	**1**						**2**	**1**			**1**		
CO6	**1**	**3**			**1**			**2**	**1**	**2**			**1**		

Course Code: ME(M2)/PC/B/S/223	Course Name: Heat Power Laboratory – I (Thermodynamics and Heat Transfer Laboratory)	
Credits: 1	Contact Hours/Week (L-T-P): 0-0-2	Full Marks: 100
Category of Course: PC	Nature of Course: Sessional	
Course content/Syllabus:	1. Determination of dryness fraction of steam 2. Determination of critical pressure ratio for an orifice 3. Measurement of temperature by different methods 4. Determination of thermal conductivity by Guarded Hot Plate method 5. Determination thermal conductivity of insulating powder 6. Determination of thermal conductivity of metal rod 7. Heat transfer from a pin fin 8. Natural convection from vertical cylinder 9. Determination of Emissivity of metal disc	
Course Outcomes (COs):	The students of the course should be able to CO1: Observe phenomena related to thermodynamics and heat transfer. (A1) CO2: Examine the experimental data. (K2, A2) CO3: Improve the concept through experiments. (K3, A4) CO4: Verify principles of thermodynamics and heat transfer. (K4, A5)	

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**1**						**1**	**2**						
CO2	**2**	**3**			**1**			**1**	**2**						
CO3	**2**	**3**	**1**						**2**						
CO4	**2**	**3**	**1**	**1**						**1**					

Course Code: ME(M2)/PC/B/S/224	Course Name: Applied Mechanics Laboratory – I	
Credits: 1	Contact Hours/Week (L-T-P): 0-0-2	Full Marks: 100
Category of Course: PC	Nature of Course: Sessional	

Course content/Syllabus:

Experiments on Strength of Materials and Engineering Mechanics (Deformable body mechanics and rigid body mechanics)

A. Experiments related to fundamental mechanical properties like tensile test, torsion test, bending test etc.
B. Experiments related to configurational properties of engineering components like flywheel (mass moment of inertia), spring etc.
C. Correlation between various mechanical properties tested through different techniques.
D. Preliminary concepts of experimental errors associated with mechanical testing.

Course Outcomes (COs):

The students of the course should be able to –

CO1: Experiment the basic concepts of Mechanics (Rigid Body and Deformable Body) through simple laboratory tests. (K3, A2)

CO2: Interpret the mechanical behavior of engineering materials through simple laboratory tests. (K2, A2)

CO3: Develop a comprehensive idea on data collection, analysis and presentation. (K3, A2)

CO4: Recognize the experimental errors associated with laboratory tests. (K2)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**					**1**			**1**						
CO2	**3**					**1**			**1**						
CO3		**3**						**2**	**2**	**2**					
CO4		**3**						**2**	**1**		**2**				

Course Code: ME(M2)/PC/B/S/225	Course Name: Workshop Practice – III	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: PC	Nature of Course: Sessional	

Course content/Syllabus:

Forging: Introduction to forging tools, furnaces and forging machines; to practice basic forging operations, drawing out, upsetting, necking etc.; introduction to forge welding.

Introduction to moulding practice – preparation of moulding sand and use of moulder’s tools; making of moulds by using selected pattern’s; introduction to melting and pouring practice; experiments sand testing like permeability, moisture content, shutter index, mould strength, grain fineness number etc.; demonstration of injection moulding machine.

Course Outcomes (COs):

The students of the course should be able to

CO1: Recognise various tools and accessories and their uses in forging and moulding workshops. (K2)

CO2: Explain the properties of moulding sands. (K2)

CO3: Perform the basic forging operations like drawing out, upsetting, necking etc. (S2, K2)

CO4: Demonstrate the preparation of moulds using selected patterns. (S3, K2)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**								**1**				**2**		
CO2	**3**								**1**	**2**			**1**		
CO3	**3**					**2**		**1**	**2**	**1**			**3**		
CO4	**3**					**1**		**1**	**2**	**1**			**3**		

3rd Year 1st Semester

Course Code: ME(M2)/PC/B/T/311	Course Name: Fluid Machinery-II	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	

Course content/Syllabus:	Fluid Coupling and Torque converter- Working Principle. (1 hrs) Analysis of axial flow machines: Introduction to isolated aerofoil and cascade theory-CL and CD for blade design, blade nomenclature, degree of reaction, stalling. (4 hrs) Performance characteristics: Pumps and Fans-Radial, Mixed flow and Axial flow. (4 hrs) Turbines-Francis, Kaplan and Pelton wheel-operating characteristics and Muschel curves, Governing of Turbines. (6 hrs) Dimensional analysis for fluid machinery: Dimensionless quantities and their use in design, selection and testing. (3 hrs) Cavitation: NPSH, Thoma's cavitation parameter and suction specific speed. (2 hrs) Elements of pump and turbine systems: General description and functions-foot valves, NRV, Penstock, Draft tube, regulating valves etc., Bend guide vanes and flow straightener. (6 hrs) Interaction of pumps and Turbines and systems: Series and Parallel operation of Pumps, Performance and selection of Pumps for different systems characteristics, Surging in Pipelines and method of control. (10 hrs) Introduction to Sump design - Surface and sub-surface vortices, basic geometry and dimensions. (4 hrs)
Course Outcomes (COs):	The students of the course should be able to – CO1: Explain the operations of fluid couplings and torque converters. CO2: Describe the elements, arrangements and operation of pump and turbine systems. CO3: Select fluid machine configurations based on dimensional analysis. CO4: Analyse the performance characteristics of different types and arrangements pump and turbine systems. CO5: Determine the conditions of cavitation in fluid machines.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**1**													
CO2	**3**	**1**													
CO3	**2**	**2**	**3**												
CO4	**2**	**3**	**2**												
CO5	**2**	**3**	**1**												

Course Code: ME(M2)/PC/B/T/312	Course Name: Dynamics of Machines	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	

Course content/Syllabus:	Study of dynamics of plane motion of linkages with special reference to slider-crank mechanism. Flywheels, governors, gyroscope, balancing of reciprocating and rotating masses. Free and forced vibration of single degree-of-freedom system with application to rotating unbalance, whirling of shaft – critical speed of shaft, force and displacement transmissibility; vibration measuring instruments. Natural frequency of multi-degrees-of-freedom systems; use of approximate methods for determination of natural frequency.
Course Outcomes (COs):	The students of the course should be able to – CO1: Introduce the mechanics of vibration and to impart the ideas of modeling mechanical system using a SDOF model and to analyse for its vibrational response (both free and forced)
	CO2: Provide the concepts of engine force analysis to determine unbalance force and couple, net torque output of an internal combustion engine CO3: Understated the mathematical theories of Flywheel analysis in reciprocating engine CO4: Acquire the knowledge of rotating balancing and engine force balancing for various types of engines like in-line, radial, V-engine, etc. CO5: Understand the basic mechanics of gyroscopic motion and its applications CO6: Acquire the fundamental knowledge of governing mechanism as a mechanical feedback system and to understand its various characteristics

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**3**	**1**											**1**	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO2	**3**	**3**	**3**	**1**										**1**	
CO3	**3**													**2**	
CO4	**3**	**2**	**2**											**2**	
CO5	**3**	**2**												**2**	
CO6	**3**	**2**												**2**	

Course Code: ME(M2)/PC/B/T/313	Course Name: Internal Combustion Engine	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	

Course content/Syllabus:

Introduction: Principle of working, SI and CI engines, Two-stroke and Four-stroke engines, Components of I.C. Engine. **2Hours**

Cycles: Analysis of air standard cycles (Otto, Diesel, Dual), fuel-air cycles and actual cycle. **3Hours**

Fuels: Review of the family of hydrocarbon fuels, Classification of I.C. engine fuels, Desirable characteristics of SI &CI engine fuels, Rating of SI &CI engine fuels, Alternative fuels for SI and CI engine (liquid, gaseous, hydrogen, LPG, CNG, Biogas etc.), Air requirement, Analysis of combustion products, HHV and LHV of fuels. **5Hours**

Fuel Introduction in SI engine: Carburetion: Air-fuel ratio requirement, Working principle, Analysis of a simple carburetor, SI engine injection, mechanical &electronic fuel injection systems and their control. **5Hours**

Fuel Introduction in CI engine: Classification of diesel fuel injection systems, Working principle, Engine requirements, Injection pumps and nozzles. **2Hours**

Ignition: Battery, magneto and electronic ignition systems, Ignition timing and spark advance. **5Hours**

Combustion: Theories of normal and abnormal combustion in SI &CI engine, parameters influencing combustion, prevention of abnormal combustion in SI &CI engine. Types of combustion chamber &principle of combustion chamber design in SI &CI engine. **5Hours**

Supercharging and Scanvenging: Engine requirements, supercharging limits, turbocharging. Scavenging of two stroke SI &CI engine, scavenging parameters, ideal &actual scavenging processes, scavenging pumps. **3Hours**

Lubrication: Principle of lubrication, properties of lubricating oil, lubrication systems. **2Hours**

Cooling: Principle of cooling, air & water cooling systems. **1Hour**

Performance and Testing: Performance parameters and their measurement, different types of dynamometers, heat balance, performance characteristics, governing methods. **5Hours**

Pollutant Emission: Formation and control of pollutants. **2Hours**

Recent Developments of Engines: HCCI engines, Wankel engines, Hybrid vehicle engines. **2Hours**

Course Outcomes (COs):

The students of the course should be able to

CO1: Describe engine components, thermodynamic cycles, fuels and emissions.

CO2: Apply thermo-fluid concepts and principles for analyzing engine components.

CO3: Analyze engine performances.

CO4: Formulate design concepts on subcomponent levels.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**1**				**2**	**2**								
CO2	**2**	**3**	**1**			**2**	**2**								
CO3	**2**	**3**	**2**			**2**	**2**							**1**	
CO4	**1**	**2**	**3**	**2**		**2**	**2**							**2**	

Course Code: ME(M2)/PC/B/T/314	Course Name: Design of Machine Elements - II	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	

Course content/Syllabus:

Design of - Screw joints / bolted joints, Transmission screws, Riveted joints and welded joints (12pds)

Design of shaft coupling (rigid and flexible) (4 pds)

Clutches: Use of clutch, Classification of clutches based on actuating method, operating principle, coupling method, Description of friction clutch, automatic type disc clutch, hydraulically operated multiple disc clutch, mechanically operated clutch release mechanism, Actuating force and frictional torque equation

	based on uniform pressure and uniform wear, friction material, Simple calculation of heat release rate, Cone clutch, centrifugal clutch, problems (7pds). Brakes: Band Brake, short shoe brake, self-energizing and de-energizing brake, long shoe drum brake – pressure distribution, force and torque analysis etc. (6pds). Belt drive: Design of belt (Flat Belt and V- Belt) and pulley (5 pds). Chain drive: Types, roller chain- constructions, polygonal effect, Design of chain drive, selection from catalogue (4pds).
Course Outcomes (COs):	The students of the course should be able to: CO1: Describe the working principles of various machine elements viz. joints, brakes, clutches, belt and chain drives. CO2: Apply the basic concepts to design various machine elements viz. joints, brakes, clutches, belt and chain drives. CO3: Solve simple problems related to various machine elements. CO4: Apply the principles of design to solve complex/ real life problems involving various design codes and standards.
CO-PO Mapping:	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**		**1**			**1**									
CO2	**1**	**3**	**2**												
CO3	**1**	**2**	**3**		**1**				**1**						
CO4	**1**	**2**	**1**	**3**				**1**						**2**	

Course Code: ME(M2)/PC/B/T/315	Course Name: Machining Technology and Metrology	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	

Course content/Syllabus:	Machining- Machining principles, motions required and chief elements in machining; basic idea of machine tool; classification/ types of machine tools. Basic machine tools- Lathe, shaping machine, planning machine, slotting machine, drilling machine, milling machine, broaching machine, and grinding machine- their important constructional features and mechanisms; basic and auxiliary motions, types, specifications and applications/ operations, including taper turning, thread cutting, gear cutting, helical milling etc.; estimation of machining time; job holding devices, indexing and elementary idea about jigs and fixtures; honing, lapping and super-finishing processes. Preparation of process sheet. Cutting tools - Materials of cutting tools, elementary idea of tool geometry, tool wear etc. Introduction to the principles and applications of non-conventional machining processes; emerging areas in machining technology. Surface quality- Waviness, roughness, surface integrity; influence of surface unevenness on performance of machined components. Metrology- Machining accuracy, various types of error, the concepts of maximum attainable accuracy and economically feasible accuracy, the factors affecting accuracy; principles of measuring and gauging; accuracy, precision and sensitivity of measuring instruments; line and end standards of measurement; limits, fits and tolerances; plug and snap gauges; limit gauges- Taylor’s principle; comparators; measurement of lengths, angles and tapers; optical flat- principle of use and applications; measurement of elements of threads and gears; coordinate measuring machine- an introduction; assessment of surface roughness- the various parameters and measurement principles; introduction to laser metrology.
Course Outcomes (COs):	The students of the course should be able to – CO1: Outline the basic principles of machining technology. CO2: Describe different machine tools and related operations. CO3: Describe the tool geometry and material of single point cutting tool and other cutting tools. CO4: Outline the basic principles of non-conventional machining processes. CO5: Apply the knowledge of surface quality on the performance of machined components. CO6: Apply the knowledge of metrology for measurement purpose.
CO-PO Mapping:	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**														
CO2	**3**				**1**										
CO3	**3**						**1**								

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO4	**3**						**1**								
CO5	**3**					**1**	**2**								
CO6	**3**					**1**									

Course Code: ME(M2)/PC/B/S/311	Course Name: Workshop Practice IVA	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: PC	Nature of Course: Sessional	

Course content/Syllabus:

Introduction to machine tools - lathes, drilling machines, shaping machines, planning machines, slotting machines, milling machines, grinding machines; machine shop work involving different operations by using above mentioned machines through making of jobs.

Experiments on: Study of the speed structure of a lathe, study of apron mechanism and calibration of feeds in a lathe.

Study and grinding of various cutting tools.

Course Outcomes (COs):

The students of the course should be able to

CO1: Discuss different types of machine tools like lathes, drilling machines, shaping machines, planning machines, slotting machines, milling machines, grinding machines.

CO2: Perform different machining operations on Lathe to manufacture a pin including thread cutting operations.

CO3: Perform different machining operations on Lathe to manufacture a lathe center.

CO4: Calibrate the performance of apron mechanism, speed structure and feed of a lathe.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**1**								**2**	**1**		**2**		
CO2	**2**	**1**				**2**			**2**	**1**			**3**		
CO3	**2**	**1**				**2**			**2**	**1**			**3**		
CO4	**3**	**2**				**2**			**2**	**1**			**2**		

Course Code: ME(M2)/PC/B/S/312	Course Name: Metrology and Metallography Lab. A	
Credits: 1.0	Contact Hours/Week (L-T-P): 0-0-2	Full Marks: 100
Category of Course: PC	Nature of Course: Sessional	

Course content/Syllabus:

Metrology Lab.: Introduction to Metrology Laboratory; Ideas of different standards of Measurement; Study and use of slip gauges; Calibration of different measuring instruments and gauges; Measurement of length, diameter, taper and angle by means of different measuring instruments and gauges; Measurement of eccentricity, concentricity and estimation of errors.

Use of comparator, Optical flat, Profilometer, Tool makers' microscope and surface roughness measuring instrument; Measurement of different elements of Thread and Gear; Concept of quality control and inspection; Concept of process capability.

Metallography Lab: Study of metallurgical microscope and other accessories; Heat treatment of different samples; Preparation of specimens for study of microstructure; Mounting of specimen for metallographic study. Preparation and study of microstructures of cast iron; Study of microstructure mild steel (annealed); Study of microstructure of mild steel (hardened); Study of microstructure of welded specimen; Study of microstructure of powder metallurgy specimen; Study of electroless coated substrate.

Course Outcomes (COs):

The students of the course should be able to –

CO1: Describe a metallurgical microscope and other accessories present in the metallography laboratory.

CO2: Performmounting of specimen for metallographic study.

CO3: Build specimens for metallographic examinations.

CO4: Recognize the operation of different metrological instruments.

CO5: Calibrate different length and angle measuring instruments based on different metrological standards.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**				**2**								**2**	**1**	
CO2	**2**								**1**				**3**	**1**	
CO3	**2**								**2**				**3**	**2**	
CO4									**1**				**3**	**2**	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO5									1				3	2	

Course Code: ME(M2)/PC/B/S/313	Course Name: Applied Mechanics Laboratory - II
Credits: 1.0	Contact Hours/Week (L-T-P): 0-0-2 ; Full Marks: 100
Category of Course: PC	Nature of Course: Sessional
Course content/Syllabus:	Experiments on Strength of Materials, Engineering Mechanics, Dynamics of Machines, Vibration. Determination of the hardness of various engineering materials, Determination of the moment of inertia of mechanical components like connecting rod, disc, etc., Strain measurement using strain gauges, Bucking test of columns; and related experiments.
Course Outcomes (COs):	The students of the course should be able to – CO1: Experiment the basic concepts of Mechanics (Rigid Body and Deformable Body), Dynamics of Machines and vibration through simple laboratory tests. CO2: Interpret the mechanical behavior of engineering materials through simple laboratory tests. CO3: Develop a comprehensive idea on data collection, analysis and presentation. CO4: Recognize the experimental errors associated with laboratory tests.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3					1			1						
CO2	3					1			1						
CO3		3						2	2	2					
CO4		3						2	1		2				

Course Code: MEME(M2)/PR/B/S/314	Course Name: Minor Project
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3 ; Full Marks: 100
Category of Course: PS	Nature of Course: Sessional
Course content/Syllabus:	Each student has to work in topic to be completed in 1 semester. Specialization topics broadly include - (Heat Power/Fluid Mechanics/Machine Design/ Applied Mechanics/ Production. Specific choice of the topic would be from list of topics offered by the department. Students have to submit a project report to the respective supervisors and give a presentation of the work done in front of a specialization specific evaluation board. For each project, distribution of marks will be: 50 marks to be evaluated by the supervisor and 50 marks to be evaluated by the specialization specific evaluation board.
Course Outcomes (COs):	The students of the course should be able to - CO1. Appreciate the primary aspects of an engineering project work CO2: Extrapolate the understanding of engineering knowledge to formulate and execute a project CO3: Collate the results obtained and objectively analyze the information/knowledge CO4: Compile a comprehensive scientific document CO5. Display grasp of the chosen topic including the fundamentals

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2				1	2		3	1		1	
CO2	2	2	2	2	1				2	1	3	1	2	2	
CO3	2	2	3	2	2				2	2	2	1	2	2	
CO4	2	1	2	1						3	2	1	2		
CO5	3							2	1	3	1	3		2	

3rd Year 2nd Semester

Course Code: ME(M2)/PC/B/T/321	Course Name: Energy Conversion System
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0 ; Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical

Course content/Syllabus:

Vapour' Power Cycles: **4hours**

General layout of a steam power plant, Effect of operating variables on Reheat and Regenerative Rankine cycles, Cogeneration.4

Boilers: **15hours**

(i) Introduction: Classification (on different basis). Mountings and Accessories. 4

(ii) Coal and combustion: Coal analysis. Combustion calculations both mass and energy balance. Heating values, losses in boilers and its efficiency. 4

(iii) Types of coal feeding and firing methods in pf boiler. 4

(iv) Introduction to power station boiler. 1

(vii) Auxiliary heating surfaces: Super heater. Re-heater. Economizer. Air pre-heater. 2

Steam turbine: **12hours**

(i) Nozzles: Types, flow through nozzles. Nozzle efficiency. 4

(iii) Classification of steam turbines. Impulse turbine: Flow through impulse blading. Velocity diagram. Work done. Blade efficiency. 2

(iv) Multi-staging of turbines: pressure compounding and velocity compounding. 2

(v) Impulse-Reaction turbine: Flow through impulse-reaction blading. Velocity diagram.Degree of reaction.Parsons Turbine. 2

(vi) Principles of turbine governing. 1

(vii) Different losses in turbine. Blade erosion. 1

Nuclear Power Plants: Types of reactors, working principle of nuclear plants, comparison with thermal plants, India's nuclear power programme. 4**hours**

Condenser: Classification. Elements of condensing plant.Power plant condensers Air leakage-effect and removal. 2**hours**

Power plant economics: Load curve. Load factor. Utilization factor etc. Fixed and variable operating cost.

Principle of load sharing. 2**hours**

Renewable energy sources: Characteristics feature and importance of renewable energy sources, different types, basic working principles of wind, solar photo voltaic (SPV) & solar thermal. India's renewable power programme. 5**hours**

Course Outcomes (COs):

The students of the course should be able to –

CO1: Construct the thermodynamic cycles related to the steam power plants. (K3)

CO2: Illustrate the working of thermal power plant and its components. (K3)

CO3: Analyze the working of different components of a thermal power plant. (K4)

CO4: Explain the energy generation in nuclear and renewable energy systems. (K2)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**										**1**		**2**	
CO2	**3**	**2**	**2**			**1**	**1**					**1**		**1**	
CO3	**2**	**3**	**2**			**1**	**2**					**1**		**2**	
CO4	**3**	**1**	**1**			**1**	**2**					**1**		**1**	

Course Code: ME(M2)/H/B/T/322	Course Name: Industrial Management	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: H	Nature of Course: Theoretical	

Course content/Syllabus:	Introduction: Concepts of Management and Industrial Management; Development of management thoughts and ideas – Contribution of Taylor and others; System concepts in management [3 Hrs] Organization: Organization structure, various types, organization principles – unity of command, responsibility, authority, span of control, structural balance, communication, division of labour, etc. [3 Hrs] Types of Production – Plant location and plant layout (various types) [2 Hrs] Materials Management – Inventory – types, different cost, EOQ and EPQ models, Basic ideas of MRP and MRP II, purchasing functions, vendor rating etc., ABC analysis, Basic ideas of supply chain management [3 Hrs] Forecasting – Factors affecting demand, Types of forecasts and forecasting techniques, Time series analysis and various qualitative and quantitative forecasting techniques, forecasting errors [3 Hrs] Scheduling – Gantt chart, network scheduling – PERT, CPM, crashing [3 Hrs] Linear Programming – Fundamentals, formulations, various variables, graphical solutions etc., Sequencing – simple cases, introduction to transportation models [3 Hrs] Quality Control and Inspection – Concept of quality, quality control and inspection, Acceptance sampling – OC curve, control charts, Introduction to ISO 9000 standards, Total quality management, quality circle, brainstorming, fishbone diagram, Pareto analysis [4 Hrs] Work Study – Work measurement, time study, motion study, method study, job evaluation, merit rating [2 Hrs] Queuing Theory – Basic concept and a simple model [2 Hrs] Maintenance Management – Types of maintenance, replacement models, bath tub curve, terotechnology and some fundamentals of safety management [2 Hrs] Break Even Analysis – Some basic ideas and applications [2 Hrs] Reliability Analysis and Risk Management – Basic concepts, hazard rate, reliability functions, MTTF [2 Hrs] Basic ideas of Agile Manufacturing, Lean manufacturing, Flexible manufacturing and group technology, Ergonomics
Course Outcomes (COs):	The students of the course should be able to CO1: Classify various principles and functions of management. CO2: Solve different problems related to management of production planning and control systems. CO3: Apply various optimization tools to solve general production management problems. CO4: Analyse the fundamental management concepts in some advanced manufacturing systems. CO5: Illustrate different problems related to risk and reliability management.

CO-PO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**		**1**			**2**		**2**	**1**		**2**				
CO2	**2**	**2**	**1**	**1**	**1**	**1**	**1**				**3**				
CO3	**2**	**3**	**1**			**1**				**1**	**1**				
CO4			**3**	**2**	**1**	**1**		**2**			**1**				
CO5	**2**	**3**	**1**	**1**	**1**	**2**	**1**			**1**	**2**			**1**	

Course Code: ME(M2)/PC/B/T/323	Course Name: Design of Machine Elements - III	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	
Course content/Syllabus:	Helical springs, types of ends for extension and compression spring, spring material, set removal. Design for static and dynamic loading, Factor of safety, problems. Critical frequency of helical spring, surge and governing equation. Leaf spring: Multi leaf spring, graduated leaf spring, load-deflection equation, nipping, preloading, problems (13 pds) Design of gear drive: Spur Gear –Introduction, Modes of Gear tooth failure, Beam Strength of gear tooth and Lewis Equation, Lewis Form Factor, Service Factor, Dynamic load, Buckingham Equation, Spott's Equation, Error on gear tooth and Grade of Gear Manufacturing, Wear Strength, Derivation of load Stress Factor, Buckingham Equation for Wear, problems (8 pds) Helical Gear-Type of helical gears, virtual no. of teeth, Minimum Face width, Force analysis, Beam Strength, Dynamic load, Wear Strength, problems (4pds) Bevel Gear: Force analysis, Formative no. of teeth, Beam Strength, Dynamic load, Wear Strength, problems. (2 pds)	

	Worm gears: Uses, drawback, self locking arrangement, centre distance calculation, force analysis, friction in worm gear, efficiency, selection of material, problems (3 pds) Introduction to gear design using code. (2 pds) Pressure vessels: Thin and thick cylinders: Principal stresses, design of thickness based on failure criteria and end conditions Autofrettage: pre-stressing by plastic deformation, wire winding, compound cylinder (8 pds)
Course Outcomes (COs):	The students of the course should be able to CO1: Apply the knowledge of working principles and basic concepts to design different types of springs. (K3) CO2: Classify different types of gears according to their uses and applications. (K2) CO3: Apply design methodologies for different types of gears considering Dynamic load and Wear Strength. (K3) CO4: Design pressure vessels using basic principles and industrial codes. (K5)
CO-PO Mapping:	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**3**	**2**			**1**								**1**	
CO2	**3**					**1**								**1**	
CO3	**3**	**3**	**3**	**1**										**2**	
CO4	**3**	**3**	**3**	**1**				**2**						**2**	

Course Code: ME(M2)/PC/B/T/324	Course Name: Electrohydraulic Control Systems	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	

Course content/Syllabus:	Introduction: (7L+2T) Overall functioning and Choices of System Fluids. Applications and Comparison with other power transmission like Electrical and Electro pneumatic Systems. Basic Components and their Symbolic Representations – pump, valve, actuator, line, connector, filter, heat exchanger, accumulator and intensifier. Representation of hydraulic systems through circuit diagrams. Open Loop and Closed Loop Control Systems – block diagrams and schematics with symbols. Electrohydraulic Components with Working principles and Modelling: (16L+4T) Positive Displacement Pumps and Actuators – Classification, Schematic and Symbolic Representations with Working Descriptions, Simplified Modelling of pump and actuator. Valves – Flow, Pressure and Direction Control Valves, Schematic and Symbolic Representation with Working Descriptions, Simplified Modelling of flow-pressure characteristics and flow forces. Solenoids and Permanent-Magnet Motors – Schematic and Symbolic Representations with Working Descriptions, Simplified Modelling. Elemental Modelling Analogies - Electrical Resistance, Magnetic Reluctance of Air Gap, Flow resistance in orifices and hydraulic lines. Electrical Inductance and Capacitance, Capacitance of Compressible Fluid Volume. Modelling Nonlinearities – Frictional Nonlinearities, Magnetic Hysteresis, Valve flow Characteristics – flow gain, pressure gain, leakage, threshold. System level modelling – Electrohydraulic Servo-actuation System with Proportional Valves and Servo valves Linear Control Analysis: (8L+3T) Transfer Functions, Block Diagrams and Laplace Transform, Block Diagram Reduction. Poles, Zeros, Characteristic Equations and Characteristic Polynomial. On-off and Feedback Controls, Proportional, Integral and Derivative Controllers. Time-Domain Response – Proportional Solenoid and Hydraulic Actuation, Speed of Response, Steady-State Error and Overshoot. System Stability and Routh-Hurwitz Criterion. Frequency Response – Phase-Gain plot, Gain margin and Phase margin.
Course Outcomes (COs):	The students of the course should be able to CO1: Describe basic components, applications and advantages of electrohydraulic systems and circuits. CO2: Develop elemental models of components and dynamic models of systems. CO3: Analyse the frequency and time domain responses of simple systems. CO4: Explain the principles of open-loop and closed loop controls. CO5: Design simple controllers for some basic electrohydraulic systems.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**													
CO2	**3**	**2**	**2**												
CO3	**2**	**2**	**3**		**1**									**1**	
CO4	**3**	**2**	**1**												
CO5	**2**	**2**	**3**	**2**	**1**									**1**	

Course Code: ME(M2)/PC/B/TS/326	Course Name: Measurement & Instrumentation	
Credits: 3	Contact Hours/Week (L-T-P): 2-0-2	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	

Course content/Syllabus:

THEORY: 2 X 14 (weeks) = 28 periods

Introduction–

•Application and importance of mechanical measurement systems and instrumentation
•Functional elements of an instrument.
•Active Passive transducers.
•Analog/digital mode of operation.
•Null/deflection methods of measurement.
•Generalized I/O configuration of measurement systems. 3 periods **Methods of correction of interfering and modifying inputs**. 2 periods **Static characteristics**:
•Static sensitivity. Linearity, Threshold, noise floor, Resolution, Hysteresis Dead space, Span, Scale readability
•Basic statistics.
•Static calibration • Uncertainty analysis.
•Least square calibration curve. 6 periods **Loading effects**. 2 periods **Dynamic characteristics**:
•Generalized mathematical model,
•Operational and sinusoidal transfer functions.
•Zero order instrument.
•First order instrument: Step, Ramp response of first order instruments.
•Second order instruments: Step, Ramp response of second order instruments.
•Logarithmic plotting of frequency response curves. 8 periods **Different instruments/measurement systems**:
•Principles for measurement of Displacement/Strain/Acceleration, Force/Pressure, Flow, Temperature. 6periods

Introduction to Signal conditioning and Data acquisition systems 3 periods

LABORATORY: 14 (weeks)

Measurement of the following physical variables with suitable instruments/measurement systems:

•Geometric sizes
•Displacement/velocity/acceleration
•Force/pressure
•Flow
•Temperature

highlighting the following measurement principles:

•Functional elements of an instrument, I/O configuration
•Methods of correction of interfering and modifying inputs
•Static characteristics
•Loading effects
•Dynamic characteristics

Signal conditioning and Data acquisition systems

Course Outcomes (COs):	The students of the course should be able to – CO1: Understand the application and significance of mechanical measurement systems and instrumentation. (K2) CO2: Apply basic statistical methods to analyse and interpret measured data. (K3) CO3: Analyse the static and dynamic characteristics of measurement systems and evaluate loading effects. (K4) CO4: Develop and utilize generalized mathematical models for measurement systems. (K5) CO5: Apply principles for measuring displacement, strain, force, pressure, flow, and temperature using various instruments and systems. (K3)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**					**2**									
CO2	**2**	**3**							**2**				**3**		
CO3	**2**	**3**	**1**						**2**				**3**		
CO4	**2**	**2**	**2**												
CO5	**3**	**3**	**2**	**2**					**2**				**3**		

Course Code: ME(M2)/PC/B/S/321	Course Name: Workshop Practice IVB	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: PC	Nature of Course: Sessional	
Course content/Syllabus:	Introduction to machine tools - lathes, drilling machines, shaping machines, planning machines, slotting machines, milling machines, grinding machines; machine shop work involving different operations by using above mentioned machines through making of jobs. Experiments on: Study of the speed structure of a lathe, study of apron mechanism and calibration of feeds in a lathe. Study and grinding of various cutting tools.	
Course Outcomes (COs):	The students of the course should be able to – CO1: Perform different operations in lathe and milling machine on a gear blank. CO2: Perform different operations on a slotting machine to produce keyway in the gear. CO3: Perform different operations in shaping machine to complete a V-Block. CO4: Interpret various cutting tool geometry.	

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**	**1**				**2**			**2**	**1**			**3**		
CO2	**1**	**1**				**2**			**2**	**1**			**3**		
CO3	**2**	**1**				**2**			**2**	**1**			**3**	**2**	
CO4	**3**	**2**			**1**				**1**	**2**				**1**	

Course Code: ME(M2)/PC/B/S/322	Course Name: Metrology and Metallography Lab. B	
Credits: 1	Contact Hours/Week (L-T-P): 0-0-2	Full Marks: 100
Category of Course: PC	Nature of Course: Sessional	
Course content/Syllabus:	**Metrology Lab.:** Introduction to Metrology Laboratory; Ideas of different standards of Measurement; Study and use of slip gauges; Calibration of different measuring instruments and gauges; Measurement of length, diameter, taper and angle by means of different measuring instruments and gauges; Measurement of eccentricity, concentricity and estimation of errors. Use of comparator, Optical flat, Profilometer, Tool makers' microscope and surface roughness measuring instrument; Measurement of different elements of Thread and Gear; Concept of quality control and inspection; Concept of process capability. **Metallography Lab:** Study of metallurgical microscope and other accessories; Heat treatment of different samples; Preparation of specimens for study of microstructure; Mounting of specimen for metallographic study. Preparation and study of microstructures of cast iron; Study of microstructure mild steel (annealed); Study of microstructure of mild steel (hardened); Study of microstructure of welded specimen; Study of microstructure of powder metallurgy specimen; Study of electroless coated substrate.	

Course Outcomes (COs):	The students of the course should be able to CO1: Relate the property-microstructure correlation of cast iron. CO2: Recognize microstructures of different specimens like mild steel, welded specimen, powder metallurgy specimen, electroless coated specimen. CO3: Assess the attributes of complex shapes as in gear and thread CO4: Assess the attributes of surface topography of machined surfaces

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**								**1**				**2**	**1**	
CO2	**3**								**1**				**2**	**1**	
CO3									**1**				**3**	**2**	
CO4									**1**				**3**	**2**	

Course Code: ME(M2)/PC/B/S/323	Course Name: Machine Design Sessional	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: PC	Nature of Course: Sessional	

Course content/Syllabus:	Introduction to Solid Modeling: Advantages and Applications, 3-D modeling software, Present status in industry, Familiarization with modeling software, User interface, Menus and tools, Model tree, Work environment and File management (3 pds) Sketching: 2-D Sketching, Sketching entities and relations, Editing sketches (3 pds) Basic Part Modeling: Extrude, Revolve, Hole feature, Fillet, Chamfer, Mirror (6 pds) Advanced Part Modeling: Datum/Reference plane and axis, Pattern (Rectangular and Circular), Sweep, Helical sweep, Advanced sweep features, Rib, Draft, Shell feature (9 pds) Assembly: Assembly interface, Inserting components in assembly, Constraints/Mating features, Interference detection, Sectional view, Exploded view (9 pds) Detailed Drawing from Model/Assembly: Drafting overview, Adding drawing views, Dimensioning, Bill of materials and tables (3 pds) Advanced Topics: Static stress analysis of simple machine components, Motion analysis of simple mechanisms, Demonstration of 3D printing of simple machine components (9 pds)
Course Outcomes (COs):	Students should be able to - CO1: Describe the basic philosophy, advantages and applications of solid modeling
	CO2: Apply solid modeling concepts and commands to model simple machine parts CO3: Construct complex machine parts with the help of advanced solid modeling commands CO4: Construct assemblies of different machine parts using appropriate Constraints/Mating features CO5: Develop 2D engineering drawings from Models and Assembly CO6: Analyze simple design problems from the point of view of stress or motion

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**		**1**		**2**				**1**			**1**	**2**		
CO2	**2**				**3**				**1**				**3**		
CO3	**2**	**1**	**1**		**3**				**1**				**3**		
CO4	**2**	**1**	**1**		**3**				**1**			**1**	**3**	**1**	
CO5	**2**				**3**				**1**			**1**	**3**	**1**	
CO6	**2**	**1**	**2**		**3**				**1**				**3**	**1**	

Course Code: ME(M2)/PC/B/S/324	Course Name: Fluid Machinery Lab.	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: PC	Nature of Course: Sessional	

Course content/Syllabus:	Study of the performance characteristics of centrifugal pump, blower, water turbines, jet pump. Study of cavitation – characteristics of centrifugal pump. Study of oil-hydraulic system including the characteristics of fluid power components such as pressure control valve, flow control valve, study of the characteristics of fluid control circuit using pneumatics servo system. Study of the characteristics of submerged jet. Study of supersonic wind tunnel technique. Determination of pressure distribution around an aerofoil. Application of analogy technique in fluid mechanics.

Course Outcomes (COs):	The students of the course should be able to CO1: Follow operations of sample industry-grade devices. CO2: Extract primary variables from measurements and catalogue information. CO3: Determine performance characteristics for hydraulic machines. CO4: Operate fluid systems with accessories for conducting experiments. CO5: Prepare experimental reports.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**	**1**						**2**	**1**			**1**		
CO2	**2**	**3**							**2**	**1**			**1**		
CO3	**2**	**3**	**2**						**2**	**1**			**1**		
CO4	**2**	**3**	**2**		**2**				**2**	**1**			**1**		
CO5	**2**	**3**			**2**			**2**	**1**	**2**			**1**		

4th Year 1st Semester

Course Code: ME(M2)/PC/B/T/411	Course Name: Design of Machine Elements - IV	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	
Course content/Syllabus:	Design of rotors: Shafts and axles with bearing mountings, High-speed rotor-constant thickness and variable thickness, limit speed analysis, interference fits in rotors (5 pds) Rolling contact bearings Types, static load capacity-Stribeck equation, dynamic load capacity, equivalent load, load-life relation, bearing life selection, load factors. (3 pds) Bearing selection from Manufacturer's catalogues, selection of taper roller bearing (2 pds) Design for cyclic load and speed (2 pds), Bearing reliability, lubrication, mountings (2 pds) Sliding contact bearings: Lubricant properties, types of lubrications, Petroff equation, Stribeck curve (2 pds) Tower experiment, Hydrodynamic theory, Pressure development, Reynold's equation (4 pds) Long and short bearing theory, finite bearing solution, Raimondi-Boyd Charts (2 pds) Design of hydrodynamic journal bearings (3 pds), Hydrostatic bearings –circular stepped thrust bearing (2 pds) Design optimization: Concept and applications of optimization in design, Algorithm for single variable (Bracketing region elimination and fitting method), multi-variables (gradient based and direct search), and constrained optimization, Concept of evolutionary algorithm (10) System design: Gear box design (5 pds)	
Course Outcomes (COs):	The students of the course should be able to CO1: Apply the basic failure theory with ASME/IS Code for design of high speed rotors. (K3) CO2: Explain the basic principles of lubrication. (K2)	
	CO3: Assess the design principles of hydrodynamic journal and thrust bearings, hydrostatic bearings, squeeze bearing, gas bearing etc. (K3) CO4: Appraise the concepts of optimization in system design. (K4) CO5: Design engineering systems such as a gear box. (K6)	

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**	**2**	**3**	**1**		**1**		**1**						**1**	
CO2	**3**	**2**													
CO3	**2**	**2**	**3**											**1**	
CO4	**3**	**1**	**1**		**1**		**1**					**1**			
CO5	**3**	**3**	**2**	**1**		**2**		**1**						**2**	**1**

Course Code: ME(M2)/PC/B/T/412	Course Name: Refrigeration and Air Conditioning	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100

Category of Course: PC	Nature of Course: Theoretical
Course content/Syllabus:	**Introduction:** Concepts of Refrigeration and Air-conditioning. Unit of refrigeration, Reversed Carnot cycle. 2**Hours** **Simple Vapour Compression Refrigeration System (Simple VCRS):** Modifications in reversed Carnot cycle with vapour as a refrigerant, Vapour compression cycle on p-h and T-s diagrams. Cycles with subcooling and superheating, their effects; Effect of changes in evaporator pressure and condenser pressure on the performance of a simple VCRS, Dry compression and wet compression of refrigerant, Actual Vapour Compression Cycle 4**Hours** **Multi pressure System:** Multistage or compound compression with intercooler, flash gas removal and flash intercooler, multi-evaporator systems with individual and multiple expansion valves, cascade system 3**Hours** **Refrigerants:** Classification, nomenclature, desirable properties- Ozone depletion potential (ODP) and global warming issues 1**Hours** **EquipmentsAnd Control:** Major Refrigeration Equipment - Compressors: Types; reciprocating, rotary & centrifugal, volumetric efficiency, Condensers: types used in refrigeration systems; Evaporators: expansion devices: capillary tubes and thermostatic expansion valves. 6**Hours** Basic definitions and principles related to Psychometry; Properties of moist air, temperature and humidity measuring instruments, Psychometric Charts & their uses; Heating, cooling, heating & humidification, cooling & dehumidification, cooling & humidification processes. Adiabatic saturation, By-pass factor, Sensible Heat Factors. 6**Hours** Heat Load estimation: Heat gain by solar radiation, Sol-Air temperature, Heat transfer through building structure**,** Summer air conditioning and winter air-conditioning, Estimation of the cooling capacity of the system. 4**Hours** Air-conditioning systems and equipment: window air conditioners & split air conditioners, Central air conditioning system**:** chillers, air handling units, cooling towers and cooling coils. 5**Hours** Air Refrigeration System (ARS): open-air and dense-air system, limitations of Bell- Coleman refrigerator. COP determination, actual air-refrigeration cycle, Bootstrap, Regenerative air refrigeration systems. 3**Hours** Vapour Absorption Refrigeration System (VARS): Advantages of VARS over VCRS. Working principle of simple VARS, practical VARS. Limitations of VARS, maximum COP of a VARS, Lithium bromide-water System; Aqua-ammonia systems, Solar energy based refrigeration systems 4**Hours** Other Refrigeration Systems: Basic idea of Thermoelectric refrigeration system; Steam-jet (vapour-jet) refrigeration system, Vortex tube. 1**Hours**
Course Outcomes (COs):	The students of the course should be able to CO1: Understand the associated laws of thermodynamics and thermodynamic mixture properties with refrigeration and psychometric systems. (K2) CO2: Describe refrigeration cycles, components, refrigerants and psychrometric processes. (K1) CO3: Apply engineering concepts and principles on refrigerator and air-conditioning system components. (K3) CO4: Analyze component and system performances. (K4) CO5: Formulate design and operation at subcomponent levels. (K5)
CO-PO Mapping:	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**														
CO2	**3**	**1**					**2**								
CO3	**2**	**3**	**1**				**2**						**1**		
CO4	**2**	**3**	**2**			**2**	**2**							**1**	
CO5	**1**	**2**	**3**	**2**	**1**		**2**							**2**	

Course Code: ME(M2)/PC/B/T/413	Course Name: Metal Cutting and Machine Tools	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	

Course content/Syllabus:	Theory of metal cutting: tool geometry, specification, conversion and selection; basic mechanisms and geometry of chip formation of orthogonal cutting, continuous and discontinuous chips, built up edge; mechanics of metal cutting, theory, measurement of shear angle; tool dynamometer; thermal aspects of metal cutting; weld theory of friction and action of metal cutting fluids, tool wear and tool life; economics of machining. Machine tool: features of construction: layout of speed for various machine tool drives; introduction to hydraulic and electric drives; design of gear boxes for speed and feed changes; rigidity and vibration analysis. Numerical control machine tools: basic concepts, field of applications, coordinate system and machine motions, types of NC systems, MCU and other components, NC part programming- manual and computer assisted; engineering analysis; CNC, DNC. Basic concepts of open loop, closed loop and adaptive control systems.
Course Outcomes (COs):	The students of the course should be able to – CO1: Identify cutting tool nomenclature, represent and correlate in different reference systems. CO2: Analyse tool wear mechanisms, parameters on tool life and economics of machining. CO3: Explain principles and mechanics of metal cutting. CO4: Apply design aspects of some elements of machine tools CO5: Describe the operation of numerical control machine tools

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**													
CO2	**3**	**2**	**1**				**2**				**2**			**2**	
CO3	**3**	**3**	**2**	**2**										**2**	
CO4	**3**	**3**	**3**											**2**	
CO5	**3**	**2**	**2**		**2**									**2**	

Course Code: ME(M2)/PS/B/S/411	Course Name: Workshop Practice - VA	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: PS	Nature of Course: Sessional	

Course content/Syllabus:	Manufacturing / making the components of a complete equipment / device/ machine tool, like reciprocating pump / drilling machine/ Centrifugal pump/ some other – fitting, machining, assembly work and testing. Experiments in metal cutting: study of chip formation mechanism and influence of various parameters on shear angle; determination of force, temperature, tool life etc. Alignment test of machine tools, other experiments on machine tool /machining (study of machine tool rigidity& vibration etc.). Study and operation of gear generating machines, auto-screw machine, broaching machine, cylindrical grinding machine, CNC lathe; Introduction to machining center etc.; study of non-conventional machining.
Course Outcomes (COs):	The students of the course should be able to – CO1: Perform acceptance and alignment tests of machine tools. CO2: Interpret chip formation mechanism and related technical parameters. CO3: Explain the elementary functioning of an auto-screw cutting machine. CO4: Organize the steps leading to fabrication of reciprocating pump components.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**	**3**		**1**					**2**	**2**	**1**		**2**	**1**	
CO2	**3**				**2**				**2**	**2**			**1**		
CO3	**3**				**2**				**1**	**2**			**1**		
CO4	**2**	**1**							**2**	**1**			**3**	**1**	

Course Code: ME(M2)/PC/B/S/412	Course Name: Heat Power Lab.-II (Devices)	
Credits: 1	Contact Hours/Week (L-T-P): 0-0-2	Full Marks: 100
Category of Course: PC	Nature of Course: Sessional	

Course content/Syllabus:	1. Parallel flow/counter flow heat exchanger 2. Cross flow heat exchanger 3. Refrigeration laboratory unit 4. Air conditioning laboratory unit 5. Steam turbine 6. Study of boiler 7. Valve timing diagram of I.C. engine 8. Performance test of I.C. engine
Course Outcomes (COs):	The students of the course should be able to – CO1: Observe phenomena related to thermal devices CO2: Examine the experimental data CO3: Improve the concept through experiments CO4: Verify principles of different thermal devices
CO-PO Mapping:	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1						1	2						
CO2	2	3			1			1	2						
CO3	2	3	1						2						
CO4	2	3	1	1						1				1	

Course Code: ME(M2)/PR/B/S/413	Course Name: Colloquium	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: PS	Nature of Course: Sessional	
Course content/Syllabus:	Each student will be required to submit to the class teacher at least four different articles containing about 2000 words on four engineering topics assigned by the class teachers, and will be required to give concise talks on those topics in the class according to the direction of the class teacher, and will have to participate in the discussion on such talks of the other students also. The result of those assignments will be considered as that of practical work. There will be no written examination for this course.	
Course Outcomes (COs):	The students of the course should be able to CO1: Acquaint themselves towards a given domain of engineering topics. CO2: Compose technical report on given engineering topics. CO3: Defend the report of their work before a technical forum. CO4: Practice interactive/group discussion on given engineering and associated topics.	
CO-PO Mapping:		

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2				2	2				2	3			1
CO2	1	2				2	2	2		3	2				1
CO3		2			1	2	2			3	2				
CO4		2				2	2		3		2				1

Course Code: ME(M2)/PR/B/S/414	Course Name: Project (Major)	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: PS	Nature of Course: Sessional	
Course content/Syllabus:	Each student has to work on a single topic with the same supervisor for 2 semesters. In contrast to the major project the work needs to be more extensive. Specialization topics broadly include - Heat Power/Fluid Mechanics/Machine Design/ Applied Mechanics/ Production. Specific choice of the topic would be from list of topics offered by the department. Students have to submit a project report to the respective supervisors and give a presentation of the work done in front of a specialization specific evaluation board after every semester. For each semester, distribution of marks will be: 50 marks to be evaluated by the supervisor and 50 marks to be evaluated by the specialization specific evaluation board.	
Course Outcomes (COs):	The students of the course should be able to CO1. Conceptualize and organize the planning of a proposed engineering project CO2: Execute the steps required for realization of the project CO3: Collate the results obtained and objectively analyze the information/knowledge CO4: Compile a comprehensive scientific document CO5. Display grasp of the chosen topic including the fundamentals and future scope	

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2				1	2		3	1		1	
CO2	2	2	2	2	1				2	1	3	1	2	2	
CO3	2	2	3	2	2				2	2	2	1	2	2	
CO4	2	1	2	1						3	2	1	2		
CO5	3							2	1	3	1	3		2	

4th Year 2nd Semester

Course Code: ME(M2)/HS/B/T/421	Course Name: Engineering Economics and Costing	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: HS	Nature of Course: Theoretical	

Course content/Syllabus:	Introduction: engineering economy and its importance, want activity – satisfaction of wants. Resource planning and distribution in economic systems – Laissez. Factors of production: the concept of optimum, laws of return; demand - elasticity of demand – demand estimation market research; supply and industrial costs. Money-value of money; quantity theory; inflation and deflation. Banking: role of commercial banks; credit and its importance in industrial functioning – source of finance; Reserve bank of India and its functions. Business management and organisation: proprietorship, partnership and joint-stock company – their formation.
	Finance and management: elements of taxation, insurance, business combinations, basic principles of management. Industrial record-keeping: double entry system, journal, ledger, trial balance, cash book, preparation of final accounts – trading, profit and loss account, balance sheet, simple study of balance. Industrial costs: classification – material cost control, labour cost control and overhead cost control; depreciation and replacement studies. Financial control: ratio analysis and their interpretation for industrial control; budgetary control. Value analysis and project evaluation: pay back, DCF, IRR.
Course Outcomes (COs):	The students of the course should be able to CO1: Interpret the basic dynamics of economic forces both micro and macro. CO2: Interpret financial statements including balance sheets. CO3: Solve simple accounting and finance related problems. CO4: Explain roles of commercial banks, Reserve Bank of India, forms of business organization and various types of business combinations from Indian perspective. CO5: Develop cost sheet and budget for simple business cases.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1				2						1			
CO2	2	3	2									1			
CO3	2	3				1		1				1			
CO4	3					1						1			
CO5	2	3						1				2			

Course Code: ME(M2)/PC/B/T/422	Course Name: Material Handling	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: PC	Nature of Course: Theoretical	

Course content/Syllabus:	Definition of material handling, classification of materials, bulk load, unit load, their characteristics Classification of mechanical handling equipment, different types of elevators and lowerers for handling materials in bulk and unit loads, their working principles and estimation of handling capacity. Belt conveyors and their construction, capacity and power requirements, other conveyors loke apron, steel plate and slat conveyors, flight and screw conveyors, vibrating and oscillating trough conveyors – estimation of handling capacity and power requirement, Automatic feeding devices for elevators and conveyors. Gravity chutes and gravity roller runways accessories of gravity roller conveyors viz. humper, stacker and gadget, live rollers, pneumatic and hydraulic methods of conveying, monorails, and blast furnace hoists. Loading/unloading and operation of railway wagons, motor trucks and fork lift trucks. Wire ropes, pulley blocks, crab winch, grabs and lifting magnets, different types of cranes. Definition and types of robots – basic concept, working principle and application of robotics, manipulators. Automation, Automated Guided Vehicles (AGVs) and application, Automated production and transfer lines.
Course Outcomes (COs):	The students of the course should be able to – CO1: Describe the objectives and scope of Material Handling Equipment for different kinds of loads CO2: Classify the Material Handling Equipment under conventional and non-conventional types CO3: Illustrate different Material Handling Equipment according to their principles of operation and applications CO4: Analyze real life applications with reference to theoretical concepts
CO-PO Mapping:	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**													
CO2		**3**													
CO3	**3**	**2**	**1**												
CO4	**2**	**3**		**1**											

Course Code: ME(M2)/PS/B/S/421	Course Name: Workshop Practice - VB	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: PS	Nature of Course: Sessional	
Course content/Syllabus:	[Syllabus common with Workshop Practice - VA] Manufacturing / making the components of a complete equipment / device/ machine tool, like reciprocating pump / drilling machine/ Centrifugal pump/ some other – fitting, machining, assembly work and testing. Experiments in metal cutting: study of chip formation mechanism and influence of various parameters on shear angle; determination of force, temperature, tool life etc. Alignment test of machine tools, other experiments on machine tool /machining (study of machine tool rigidity& vibration etc.). Study and operation of gear generating machines, auto-screw machine, broaching machine, cylindrical grinding machine, CNC lathe; Introduction to machining center etc.; study of non-conventional machining.	
Course Outcomes (COs):	The students of the course should be able to – CO1: Perform acceptance and alignment tests of machine tools. CO2: Interpret chip formation mechanism and related technical parameters. CO3: Explain the elementary functioning of an auto-screw cutting machine. CO4: Organize the steps leading to fabrication of reciprocating pump components.	
CO-PO Mapping:		

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**	**3**		**1**					**2**	**2**	**1**		**2**	**1**	
CO2	**3**				**2**				**2**	**2**			**1**		
CO3	**3**				**2**				**1**	**2**			**1**		
CO4	**2**	**1**							**2**	**1**			**3**	**1**	

Course Code: ME(M2)/PC/B/S/422	Course Name: Machine Elements Lab	
Credits: 1	Contact Hours/Week (L-T-P): 0-0-2	Full Marks: 100
Category of Course: PC	Nature of Course: Sessional	
Course content/Syllabus:	Experiments on the following topic: Critical speed of a rotor, Natural frequency of vibration of a beam, Balancing of rotors, Performance of hydrostatic & hydrodynamic journal bearing, NDT etc. Experiment on Robot kits, friction wear measurement.	

Course Outcomes (COs):	The students of the course should be able to CO1: Explain methods and procedures of experiments for studying properties and performance of various types of machine elements (rotors, beams, bearings etc.) CO2: Conduct experiments of various types of machine elements (rotors, beams, bearings etc.) CO3: Present the experimental observations with figures and tables. CO4: Verify theoretical predictions with experimentally obtained parameters. CO5: Explain variations observed between theoretical predictions and experimental results.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**													
CO2	**1**								**2**	**1**			**3**		
CO3	**1**				**1**			**1**		**3**					
CO4	**3**	**2**													
CO5	**3**	**2**						**1**			**1**				

Course Code: ME(M2)/PR/B/S/423 [Continuation from ME(M2)/PR/B/S/414]	Course Name: Project (Major) [Continuation from previous semester]	
Credits: 1.5	Contact Hours/Week (L-T-P): 0-0-3	Full Marks: 100
Category of Course: PS	Nature of Course: Sessional	
Course content/Syllabus:	Each student has to work on a single topic with the same supervisor for 2 semesters. In contrast to the major project the work needs to be more extensive. Specialization topics broadly include - Heat Power/Fluid Mechanics/Machine Design/ Applied Mechanics/ Production. Specific choice of the topic would be from list of topics offered by the department. Students have to submit a project report to the respective supervisors and give a presentation of the work done in front of a specialization specific evaluation board after every semester. For each semester, distribution of marks will be: 50 marks to be evaluated by the supervisor and 50 marks to be evaluated by the specialization specific evaluation board.	
Course Outcomes (COs):	The students of the course should be able to CO1. Conceptualize and organize the planning of a proposed engineering project CO2: Execute the steps required for realization of the project CO3: Collate the results obtained and objectively analyze the information/knowledge CO4: Compile a comprehensive scientific document CO5. Display grasp of the chosen topic including the fundamentals and future scope	

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**3**	**2**	**2**				**1**	**2**		**3**	**1**		**1**	
CO2	**2**	**2**	**2**	**2**	**1**				**2**	**1**	**3**	**1**	**2**	**2**	
CO3	**2**	**2**	**3**	**2**	**2**				**2**	**2**	**2**	**1**	**2**	**2**	
CO4	**2**	**1**	**2**	**1**						**3**	**2**	**1**	**2**		
CO5	**3**							**2**	**1**	**3**	**1**	**3**		**2**	

Course Code: ME(M2)/PC/H/S/424	Course Name: Advanced Laboratory and Simulation	
Credits: 4	Contact Hours/Week (L-T-P): 0-2-4	Full Marks: 100
Category of Course: PC	Nature of Course: Theory + Sessional	
Course content/Syllabus:	**ANY 1 module need to be selected by the student** **Module 1** 1. Simulation of Dynamic systems: a. Inverted Pendulum: i. Derivation of governing equations of motion	

	ii. Governing equations in state vector form iii. Pole placement technique iv. Measurement of rotation v. Relevant Actuation techniques vi. P, PD and PID control vii. Pole placement technique viii. Simulation using SIMULINK/XCOS ix. Experiments with available setup in Dynamics Laboratory b. Natural frequency and Mode shapes of beams: i. Equations of beam as a continuous system ii. Finite Element formulation iii. Study of finite element programme for beam vibration iv. Sensors and actuators for beam vibration v. FFT & FRF vi. Obtaining natural frequency and mode shapes from FRF from simulated beam models vii. Experiments preferably using modal analysis software 2. Simulation of quasi-static and Impulse tests using Linear/Nonlinear FEM: a. Simulation of necking in a tensile test. i. Material nonlinearity. ii. Geometric nonlinearity. iii. Load application. iv. Simulation of nonlinear systems. v. Convergence. vi. Post-processing. b. Simulation of Izod/Charpy tests. i. Material nonlinearity. ii. Geometric nonlinearity. iii. Load application. iv. Simulation of nonlinear systems. v. Convergence. vi. Post-processing. c. Stress analysis of Composite structures etc. **Module 2** Four topics among the following list of topics need to be completed by the student. • Theory of plate/shell – Related theory, simulation, experiment • Bending of beams - Related theory, simulation, experiment • Natural frequency/vibration - Related theory, simulation, experiment • Material properties: Tensile testing - Related theory, simulation, experiment • Material properties: Fatigue/Fracture behaviour - Related theory, simulation, experiment • Tribological testing - Related theory, simulation, experiment • Computer Aided Design - Related theory, simulation, modelling, testing • Robotics - Related theory, simulation, experiment • Synthesis of Mechanisms - Related theory, simulation, experiment • Optimization in Design - Related theory and simulation • Contact of Solids - Related theory and simulation **Module 3** Tutorial classes and demonstration of CFD techniques using CFS (Commercial Flow Solver) such as FLUENT etc. with the objective of the following: a. How to impart geometry of a particular flow process and the grid size or number of grids related with the particular geometry; How to impart the related boundary conditions, Run the CFD and getting the required results; Post processing of those results as well as plotting the velocity, pressure etc. profiles, getting streamlines/stream trace, iso-profiles etc. Derivation of some particular variables. (Total 4 hrs) b. Analyses of flow through circular pipe for the laminar flow and axi-symmetric boundary conditions considering: A. With or without impartation of swirl at the inlet B. Visualization of the flow through a sudden expansion (3 hrs.) c. Demonstration and visualization of the two-phase flow through 2-D rectangular geometry using

	LEVELSET/V.O.F. method etc. (3 hrs.) d. Marked assignment problems on CFD modeling techniques using commercial software packages, namely: The Backward-Facing Step (BFS) flows; The Lid-driven cavity problem. e. Advanced Laboratory: Performance test of a positive displacement pump using pc based control and data acquisition system. Pump testing facility using variable frequency drive (VFD), proportional solenoid valve for loading, pressure and flow sensors, pc based control of the experiment through LabView

	software. 2 hr tutorial (T)+ 4 hr practical (P) Pre-requisites: Mechanical measurement and instrumentation, Fluid Machinery, Electro hydraulic control systems f. Advanced Simulation1: Modelling and Simulation of performance of a simple valve controlled electro hydraulic system or a generic 1st order or 2nd order system using PID control. (Matlab/Simulink platform). Block diagram/transfer function modelling in Simulink, Understanding of effects of different gains in system performance, how to produce results in graphical form using Matlab. 2 hr tutorial (T)+ 4 hr practical (P) Pre-requisite: Electro hydraulic control systems g. Advanced Simulation2: Hydraulic system design using Automation Studio. Automation Studio, virtual system design. 2 hr tutorial (T)+ 4 hr practical (P) Pre-requisite: Electro hydraulic control systems It should be also mentioned here that this is an exhaustive list. Depending on the availability of facility and to fit the time frame, the items to be covered in a particular academic session will be decided by the specialisation before the start of the course. **Module 4** Laboratory scale studies and simulation of advanced problems of thermal engineering. **Module 5** (a) Theory -- Basics of simulation, discrete and continuous system simulation etc. (b) Laboratory - Statistical analysis, forecasting, queuing systems, inventory models, reliability models, quality control, surface engineering etc.
Course Outcomes (COs):	The students of the course should be able to – CO1: Understand the experimental methods and procedures to test various mechanical phenomena. CO2: Conduct experiments to determine different mechanical parameters. CO3: Comprehend the concept of modelling and simulation of different mechanical phenomena. CO4: Apply basic principles of modelling and simulation to various mechanical systems. CO5: Verify experimentally obtained/simulation generated results against theoretical/analytical values. CO6: Analyze the errors associated with experiments and simulations.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**1**		**1**					**3**	**1**		**1**	**3**		
CO2	**1**	**1**							**3**	**2**		**2**	**3**		
CO3	**2**	**1**			**3**				**1**			**1**	**3**		
CO4	**2**	**2**	**3**	**3**	**3**				**1**			**1**	**3**	**2**	
CO5	**2**	**1**		**1**	**1**				**1**			**2**	**2**	**1**	
CO6	**2**	**3**		**2**	**1**				**1**	**3**		**1**	**2**	**1**	

Elective Courses

3rd Year 1st Semester: Basic Professional Elective I

Course Code: ME(M2)/PE/B/T/316A	Course Name: Introduction to Finite Element Method	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: Basic Professional Elective I	Nature of Course: Theoretical	
Course content/Syllabus:	Direct stiffness and its use to derive stiffness matrix of spring assemblage, plane truss, space truss, plane beam and three-dimensional beam element, introduction to variational calculus, stationary principles, Rayleigh Ritz method, virtual work method, interpolation function, derivation of stiffness matrix of truss and beam elements using interpolation function, derivation of nodal equivalent loads on beams using Castigliano's theorem and interpolation functions, third point specification for three-dimensional beam elements, introduction to thermal stress, examples using MATLAB/FORTRAN programs and commercial finite element package. Plane stress problem, CST, axi-symmetric problem with axi-symmetric loading, isoparametric formulation in one and two dimensions, quadrilateral isoparametric elements, numerical integration, triangular isoparametric elements, Kirchoff's plate bending element and flat shell or folded plate elements.	

Course Outcomes (COs):	The students of the course should be able to – CO1: Describe the variational and weighted residual methods in finite element analysis using onedimensional elements. CO2: Apply finite element method in discrete structural problems (truss and beams). CO3: Apply finite element method in plane stress, plane strain and axisymmetric problems using constant strain triangles, and isoparametric quadrilaterals and triangles. CO4: Apply finite element method in thin plate problems.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**1**	**1**	**1**											
CO2	**1**	**3**	**2**	**1**	**2**								**1**	**1**	
CO3	**1**	**3**	**2**	**1**	**2**								**1**	**1**	
CO4	**1**	**3**	**2**	**1**	**2**								**1**	**1**	

Course Code: ME(M2)/PE/B/T/316B	Course Name: Optimization Techniques for Engineering Design	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: Basic Professional Elective I	Nature of Course: Theoretical	

Course content/Syllabus:	Introduction: Historical development, Engg. Application, Statement and Problem definition, Classification and techniques of optimization, Classical optimization techniques. Non-linear programming: Introduction, Formation of N.L.P Optimization methods for single variable: region elimination methods, bracketing methods, Interpolation methods. Optimization methods for multiple variable: Direct search methods, random search, simplex method, Gradient based method- Steepest descent method, Conjugate gradient method, Quasi-Newton method etc. Constrained optimization: Introduction, Direct method, Complex method. Indirect method: Penalty function method etc. Evolutionary algorithms: Quadratic Programming, Genetic Algorithm, Particle swarm optimization (PSO), Differential Evolution. Simulated annealing. Application of evolutionary algorithms and comparative study. Optimum design of Mechanisms, structural components and mechanical systems.
Course Outcomes (COs):	The students of the course should be able to - CO1: Prepare the N.L.P for optimisation in design. CO2: Illustrate the optimisation algorithms for unconstrained and constrained optimisation problem. CO3: Implement the evolutionary algorithms for optimisation problems. CO4: Distinguish the optimisation algorithm for multi-objective optimisation problems. CO5: Appraise the design optimisation of mechanisms, structural components and mechanical systems.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**	**2**	**2**											
CO2	**3**	**2**	**2**	**2**										**2**	
CO3	**3**	**2**	**2**	**2**										**3**	
CO4	**3**	**2**	**1**											**2**	
CO5	**3**	**3**	**2**	**1**										**2**	**2**

Course Code: ME(M2)/PE/B/T/316C	Course Name: Vehicle Dynamics And Automotive Suspension System	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: Basic Professional Elective I	Nature of Course: Theoretical	

Course content/Syllabus:	Stability of Vehicles Load distribution. Stability on a curved track and on a slope. Weight transfer during acceleration and braking over turning and sliding. Rigid vehicle - stability and equations of motion. Tyre Relative merits and demerits of different types of tyre. Ride characteristics. Behaviour while cornering, slip angle, cornering force. Over steer, under steer, steady state cornering. Effect of camber angle and camber thrust. Suspension Type of suspension systems, requirements, independent, non-independent suspension, dead and live axle. Spring mass frequency, choice of suspension spring rate, Calculation of effective spring rate. Wheel hop and wheel wobble. Hydraulic dampers and choice of damper characteristics. Roll axis and vehicle under the action of side forces. Suspension system design, quarter car, half car and full car modeling. Overview of passive, semi-active and active suspension system and simulation software used in industry.
Course Outcomes (COs):	The students of the course should be able to – CO1: Assess the stability and load distribution of a vehicle under different conditions CO2: Evaluate tyre performance and dynamics. CO3: Understand the basic principles related to different types of suspension systems CO4: Apply modeling and simulation techniques for design of suspension systems
CO-PO Mapping:	

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**3**												**2**	
CO2	**3**	**3**	**2**											**2**	
CO3	**3**	**3**													
CO4	**3**	**3**	**3**		**3**								**1**		

Course Code: ME(M2)/PE/B/T/316D	Course Name: Numerical Heat Transfer	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: Basic Professional Elective I	Nature of Course: Theoretical	

Course content/Syllabus:	**Introduction:** Basics of heat transfer & fluid flow, Mathematical description of fluid flow and heat transfer: conservation equations for mass, momentum, energy, General structure of conservation equations.4**Hours** **Turbulence modelling:** Reynolds-averaged Navier–Stokes equations and classical turbulence models: mixing length model, k–ε model. 3**Hours** **Discretization techniques**: Classification of partial differential equations (PDE) and their physical behaviour, finite difference methods: Taylor-Series Expansion, Evaluation of First and Second order derivatives, Truncation Error; Control volume formulations. 5**Hours** **Modelling of diffusion problems using finite volume method:** One dimensional steady state diffusion problems; discretization technique. Solution methodology for linear and non-linear problems: Point-bypoint iteration, TDMA. Two and three dimensional discretization, Discretization of unsteady diffusion problems: Explicit, Implicit and Crank Nicolson’s algorithm, Stability of solutions. 7**Hours** **Implementation of boundary conditions** Inlet, Outlet, Wall, Symmetry and Periodic or cyclic boundary condition 2 **Hours** **Modelling of convection-diffusion problems**: One dimensional convection-diffusion problem: Central difference scheme. Discretization based on analytical approach (exponential scheme). Hybrid and power law discretization techniques, Higher order schemes (QUICK algorithm). 5**Hours** **Flow modelling**: Discretization of incompressible flow equations, Pressure based algorithm: SIMPLE, SIMPLER etc. 5**Hours** **Methods for dealing with complex geometries:** Body-fitted co-ordinate grids for complex geometries, Cartesian vs. curvilinear grids, Unstructured grids 2 **Hours** **CFD analysis process:** Setting and solving a physical problem- steps, Errors and uncertainty, Verification and validation. 4**Hours Case studies** 3**Hours**

Course Outcomes (COs):	The students of the course should be able to – CO1: Comprehend the basics and mathematical description of fluid flow and heat transfer CO2: Apply finite difference and finite volume discretization techniques to heat transfer and fluid flow problems. CO3: Interpret the effect of different boundary conditions.
	CO4: Implement computational fluid dynamics (CFD) analysis for physical problems with an understanding of validation, errors and uncertainty. CO5: Illustrate different methods for dealing with complex geometries.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**											**1**			
CO2	**3**	**2**	**2**	**1**											
CO3	**3**														
CO4	**3**	**2**	**2**	**2**								**1**			
CO5	**3**	**1**	**1**	**1**											

Course Code: ME(M2)/PE/B/T/316E	Course Name: Solar Energy	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: Basic Professional Elective I	Nature of Course: Theoretical	
Course content/Syllabus:	1. Sun Earth Geometry. 3 hours 2. Fundamentals of Solar Radiation. 5 hours 3. Flat Plate Collectors, materials & construction. 2 hours 4. Thermal analysis of FPC-8 5. Performance testing of FPC. 4 hours 6. Concentrating collectors & Evacuated Tube Collectors. 6 hours 7. Economics of Solar Energy. 6 hours 8. Storage of Solar Energy. 2 hours 9. Status of solar energy in India & World. 2 hours	
Course Outcomes (COs):	The students of the course should be able to – CO1: Demonstrate knowledge of sun-earth geometry, solar radiation fundamentals, and the principles governing various types of solar collectors. CO2: Analyse and design flat plate collectors, concentrating collectors, and evacuated tube collectors. CO3: Evaluate the economic viability of solar energy systems, including storage techniques, and assess their environmental impact CO4: Analyze the current status and future trends of solar energy in India & worldwide.	

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**														
CO2	**3**	**3**	**2**											**2**	
CO3	**3**	**3**	**3**				**3**							**2**	
CO4	**3**	**3**				**2**	**3**							**2**	**3**

Course Code: ME(M2)/PE/B/T/316F	Course Name: Elements of Computational Fluid Dynamics	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: Basic Professional Elective I	Nature of Course: Theoretical	

Course content/Syllabus:	Introduction: Brief introduction of ODE (IVP and BVP) and PDE, Initial and Boundary conditions, classification of PDE, various methods to solve PDE numerically along with their advantages and disadvantages. (4 hrs) FDM and FVM: Taylor series expansion, Finite difference equations (FDE) of 1st and 2nd order derivatives, Truncation errors, order of accuracy. Extending FDM to FVM. FDM and FVM applied to steady and unsteady one- and two-dimensional heat conduction equations. Convergence, consistency, explicit, implicit and C-N methods. (10hrs) Upwinding: Upwinding of convective terms and its significance, Transportive and conservative properties. Upwind biased difference schemes and its significance. Higher order upwind schemes: second order convective schemes, QUICK. (2 hrs) Stream function-vorticity approach: Derivation of stream function and vorticity equations; derivation pressure Poisson equation. Application 2-3 problems and Computer Assignment. (4 hrs) Solution of NS equations: SMAC method for staggered grid: Predictor - Corrector step, discretization of N-S and continuity equations, Pressure correction Poisson's equation, boundary conditions (no-slip, moving wall, slip boundary and inflow conditions), outflow (zero gradient/Orlanski) boundary conditions for unsteady flows, algorithm for the SMAC method, stability considerations for SMAC method. (10hrs) Semi–implicit method (SIMPLE): Comparison with the SMAC and fully – implicit methods, algorithm for semi–implicit method, discussion on SIMPLE/SIMPLER and SIMPLEC. TDMA (Thomas), GMRES, ADI and under-relaxation. Discretization of governing equations and boundary conditions in FVM framework. Computer Assignments. (10 hrs) Errors and Uncertainty of numerical results: Diffusion and dispersion errors, Stability of 1D and 2D diffusion equation; Sources of uncertainties, studies on grid independence, time-step independence, domain independence, initial condition dependence. (2hrs)
Course Outcomes (COs):	The students of the course should be able to: CO1: Understand the basic governing equations for fluid flow and associated transport phenomena CO2: Construct numerical model for solving flow equations with a prescribed set of boundary conditions. CO3: Apply finite difference and finite volume discretization techniques to fluid flow problems.
	CO4: Implement computational fluid dynamics (CFD) analysis for physical problems with an understanding of validation, errors and uncertainty.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**3**													
CO2	**3**	**3**			**2**										
CO3	**3**	**3**	**2**		**3**								**2**	**1**	
CO4	**3**	**3**		**1**	**3**								**2**	**1**	

Course Code: ME(M2)/PE/B/T/316G	Course Name: Mechanical Measurement and Industrial Statistics	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: Basic Professional Elective I	Nature of Course: Theoretical	
Course content/Syllabus:	Mechanical Measurement: Measurement of displacement, velocity, acceleration, force, strain, temperature, pressure, flow, shock, vibration and sound. Industrial Statistics: Statistical distributions and their applications to engineering and management problems; testing of hypothesis; z, t, $\chi 2$ (chi-square) and F – test; least – square methods; failure statistics and reliability engineering; stochastic problems in engineering and management. Analysis of basic experiment and their designs; factorial experiments; randomized block design; Latin square design; orthogonal latin square; optimization using Taguchi methods and design of experiment. Markovian and non-Markovian processes; Poisson processes and diffusion processes.	
Course Outcomes (COs):	The students of the course should be able to: CO1: Interpret the basic concepts of measurement systems and statistics. CO2: Employ fundamental concepts of measurement applicable for designing of engineering systems. CO3: Apply statistical concepts to solve problems related to measurement, engineering and management. CO4: Compare performance of engineering and measurement systems using statistical techniques	

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**1**													
CO2	**1**	**2**	**3**											**1**	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO3	**2**	**2**		**3**	**1**									**1**	
CO4	**2**	**3**			**1**									**2**	

Course Code: ME(M2)/PE/B/T/316H	Course Name: Mathematical Method for Engineers	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: Basic Professional Elective I	Nature of Course: Theoretical	

Course content/Syllabus:

Module 1: Differential Equations; ordinary and partial differential equations (linear and non-linear) and their applications in engineering.

Module 2: Integral transforms (Laplace, Z- and Fourier) and its applications

Module 3: Introduction to variational calculus and its simple applications in mechanics.

Module 4: Finite difference method; finite volume; finite element methods.

Module 5: Numerical (RK2 and RK4) methods for differential equations (IVP).

Module 6: Correlation and regression analysis; multivariate analysis.

Module 7: Introduction to continuous probability distribution.

Module 8: Introduction to sampling theory.

Module 9: Index numbers; CLI and its various measures.

Module 10: Introduction to time series data, its various components, time series analysis.

Course Outcomes (COs):

The students of the course should be able to:

CO1: Demonstrate proficiency in applying differential equations, integral transforms and numerical methods to solve engineering problems involving both linear and non-linear systems.

CO2: Utilize finite difference, finite volume, and finite element methods to analyze and solve engineering problems

CO3: interpret data using correlation, regression, multivariate analysis, continuous probability distributions, and time series analysis

CO4: Apply variational calculus to simple mechanical systems

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**			**2**										
CO2	**3**	**2**												**1**	
CO3	**3**	**2**												**1**	
CO4	**3**	**3**		**1**										**1**	

Course Code: ME(M2)/PE/B/T/316I	Course Name: Introduction to Composite Structures	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: Basic Professional Elective I	Nature of Course: Theoretical	

Course content/Syllabus:

Composite materials: Classification, Mechanical Behavior, Basic Terminology, Manufacture of Composite materials; Macromechanical Behavior of Lamina: Introduction, Stress-strain relations, Biaxial Strength criterion; Micromechanical Behavior of Lamina: Determination of stiffness of composite structures; Macromechanical Behavior of a Laminate: Classical Laminated Plate theory (CLPT), Lamina stress-strain relations, Resultant force and moments; Bending of Composite Beams and plates; Failure of Composite Materials: Introduction to different failure theories, Environmental Effects.

Course Outcomes (COs):

The students of the course should be able to:

CO1: Classify composite materials based on their constituents and structures

CO2: Analyze the techniques and processes involved in manufacturing composite materials.

CO3: Differentiate between macro-mechanical and micromechanical behaviors of laminated structures.

CO4: Apply different failure theories to analyze the failure mechanisms of composite materials under various loading conditions.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**	**1**													
CO2	**3**	**2**	**2**											**2**	
CO3	**2**														
CO4	**3**	**2**												**2**	

3rd Year 2nd Semester: Basic Professional Elective II

Course Code: ME(M2)/PE/B/T/325A	Course Name: Mechanical Vibration Analysis	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: Basic Professional Elective II	Nature of Course: Theoretical	
Course content/Syllabus:	Revision free vibration and forced vibration (harmonic) of single degree-of-freedom systems with and without damping; FFT and FRF for single degree-of-freedom systems; resonance; equivalent damping; whirling of shaft and critical speed; vibration transmissibility and isolation. Response computation of vibration of single degree-of-freedom systems under arbitrary excitations; impulse response function; use of numerical technique like Runge-Kutta method to solve initial value problems in vibration. Vibration measuring instruments. Equation of motion of multi-degrees-of-freedom systems by different method. Determination of natural frequency and mode shape in multi-degrees-of-freedom systems: solution of eigenvalue problems (for small degrees of freedom); steady-state response under harmonic excitation; FRF of multi-degrees-of-freedom systems; response of multi-degrees-of-freedom system with given initial condition; mode superposition method. Free vibration of one-dimensional continuous system – transverse vibration of string, axial vibration of bar, torsional vibration of circular shaft, transverse vibration of EulerBernoulli's beam. Rayleigh Ritz method. Introduction to vibration control, passive and active vibration control, closed loop systems, simple control laws, example on simple systems.	
Course Outcomes (COs):	The students of the course should be able to – CO1: Predict the response of a single-degree-of-freedom system during free vibration. CO2: Solve the equations of motion of a single-degree-of-freedom system during forced vibration. CO3: Construct equations of motion of a multi-degrees-of-freedom system to find its natural frequency and mode shape. CO4: Predict the behaviour of a multi-degrees-of-freedom system during forced vibration.	

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**	**2**													
CO2	**3**	**2**												**2**	
CO3	**3**	**2**													
CO4	**3**	**2**													

Course Code: ME(M2)/PE/B/T/325B	Course Name: Dynamics And Control Of Electromechanical Systems	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: Basic Professional Elective II	Nature of Course: Theoretical	
Course content/Syllabus:	Dynamics of mechanical systems using Lagrange’s method, Lagrange’s equation and Hamilton’s principle. Dynamics of electrical networks, Kirchoff’s laws, Lagrange’s equation and Hamilton’s principle. Dynamics of electromechanical systems, constitutive relation for transducers, Lagrange’s equation, Hamilton’s principle. Piezoelectric systems, piezoelectric material, transducers – single and multiple, constitutive relation for transducers, Hamilton’s principle, piezoelectric beam actuator, laminar sensor, active beam with collocated actuator-sensor, piezoelectric laminates. Active and passive damping with piezoelectric transducer. Magnetic levitation of a single rigid body. Components and characteristics of magnetic bearings. Magnetic suspension of rigid and flexible rotors.	
Course Outcomes (COs):	The students of the course should be able to – CO1: Analyze the dynamics of mechanical systems using Lagrange’s equations and Hamilton’s principle CO2: Analyze electrical networks using dynamic principles CO3: Evaluate dynamics of electromechanical and piezoelectric systems	
	CO4: Explain the principles of magnetic levitation, the characteristics of magnetic bearings, and the suspension of rigid and flexible rotors	

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**3**	**3**											**1**	
CO2	**3**	**3**	**3**											**1**	
CO3	**3**	**3**	**3**											**2**	
CO4	**3**	**3**												**1**	

Course Code: ME(M2)/PE/B/T/325C	Course Name: Principles Of Engineering Tribology	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100

Category of Course: Basic Professional Elective II	Nature of Course: Theoretical

Course content/Syllabus:	Engineering Surfaces; Properties and Measurement, Surface Contact Adhesion, models, indices, adhesive surface contact. Friction, origin, theories, components, measurement, friction behavior of materials. Wear, origin, types –adhesive, abrasive, corrosive, fatigue, erosion etc., measurement, theories, delamination theory, wear debris analysis, ferrography, wear behavior of materials. Thermal Considerations in Sliding Contact, measurement of flash temperature, modeling. Surface Engineering –treatments and coatings. Liquid Lubricants: Properties and Measurement, Fluid Film Lubrication, Hydrodynamic and hydrostatic lubrication, Thrust and Journal Bearing, Squeeze Film Bearings, Gas-Lubrication, Elastohydrodynamic Lubrication Rolling Element Bearings Boundary Lubrication –metal working, Bio-tribology. Nanotribology –concept, measurement tools.
Course Outcomes (COs):	The students of the course should be able to – CO1: Describe the tribological principles for reduction of friction and wear. CO2: Apply the tribological principles for improving machine efficiency. CO3: Identify proper lubrication methods and surface engineering techniques. CO4: Explain the aspects of bio-tribology and nanotribology.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**					**1**	**2**								
CO2	**2**	**2**	**3**												
CO3	**3**		**2**				**1**							**1**	
CO4	**3**					**2**	**1**								**1**

Course Code: ME(M2)/PE/B/T/325D	Course Name: Extended Surface Heat Transfer	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: Basic Professional Elective II	Nature of Course: Theoretical	

Course content/Syllabus:	**1. Analysis of extended surfaces** (16 hrs) Heat transfer and mathematical principles Fins with convection. Simplified constraints. Fins with convection. Real constraints. Fins with radiation. Fin optimization: Calculus of variation, derivative technique, single and multi-constraints Finite differences. Steady state Finite differences. Unsteady state. **2. Heat exchanger design:** Fin-and-tube heat exchange, plate fin. (7 hrs) **3. Circumferential fin:** Bessel functions, equivalent annulus method, sector method. (5 hrs) **4. Analysis of fins with consideration of all non-linearity effects.** (6 hrs) **5. Different analytical techniques to solve non-linear fin equations.** (6 hrs)
Course Outcomes (COs):	The students of the course should be able to – CO1: Apply heat transfer and mathematical principles to analyze fins under different conditions CO2: Optimize fin performance considering steady and unsteady state conditions, and multiple constraints CO3: Design various types of heat exchangers CO4: Solve non-linear fin equations using different analytical techniques

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**3**	**3**												
CO2	**3**	**3**	**3**	**2**										**2**	
CO3	**3**	**3**	**3**											**1**	
CO4	**3**	**3**	**3**	**2**										**2**	

Course Code: ME(M2)/PE/B/T/325E	Course Name: Energy Conservation and Management	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: Basic Professional Elective II	Nature of Course: Theoretical	

Course content/Syllabus:	Energy-Economics-Environment: General Overview and Interlinks 02 Energy Conservation in Thermal Utilities: 10 i) Energy Cascading and ‘Total Energy’ Concept ii) Boilers

	iii) Furnaces iv) Steam Systems Different Industrial Waste Heat Recovery Systems: 14 Industrial Insulation: 02 Energy Conservation in Lighting Systems: 02 Energy Storage: 04 Economics of Energy Conservation: 04 Energy Management and Audit: 06
Course Outcomes (COs):	The students of the course should be able to – CO 1: Understand perspectives and need of energy conservation and management CO2: Analyze energy conservation in thermal utilities and other devices CO3: Assess performance and economic feasibility of energy conservation in devices CO4: Apply principles of energy conservation and management to different devices

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**				**3**	**2**	**1**				**1**			**2**
CO2	**3**				**2**							**1**			**2**
CO3	**3**					**3**	**2**	**2**				**1**		**2**	**2**
CO4	**3**	**2**				**3**	**2**	**2**				**1**			**2**

Course Code: ME(M2)/PE/B/T/325F	Course Name: Combustion Engineering	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: Basic Professional Elective II	Nature of Course: Theoretical	

Course content/Syllabus:

1. INTRODUCTION: Definition, need, application, classification etc. of combustion systems.
2. REVIEW: Thermodynamics (1st& 2nd law for pure, non-reacting (mixture) and reacting systems; stoichiometry, thermo-chemistry, Clausius-Clapeyron equation etc.); Conservation Equations (continuity. momentum, total & thermal energy); Fluid Mechanics; Heat Transfer.
3. MASS TRANSFER: Pick's law of diffusion; derivation of species conservation equation, solution for Stefan problem & droplet evaporation; mass transfer as an analogy to heat transfer.
4. CHEMICAL KINETICS: Classification (homogeneous/heterogeneous; explosive/non-explosive reactions);Collision theory; reaction rate and it's functional dependence; Arrhenius equation; order of reaction. Steric factor. collision frequency, activation energy etc.; Single-step chemical reaction: first / second! third order &uni-molecular/ bi-molecular/ ter-molecular reactions. Multi-step chemical reaction: consecutive/competitive/ opposing/ chain/ chain-branching etc. reactions. Explosion limits; relation between reaction rate and equilibrium constant; computation of kinetic data.
5. MODELING OF COMBUSTION SYSTEM: Connection among Fluid Mechanics, Heat Transfer, MassTransfer. Chemical Kinetics & Conservation Equations through Thermodynamics.
6. LAMINAR PREMIXED FLAME: Definition, principal characteristics; Simplified Analysis: assumptions, conservation (mass, species & energy) equations with boundary conditions and their solutions to find out temperature & mass-fraction distribution; determination of flame velocity & thickness; quenching; flammability & ignition.
7. LAMINAR DIFFUSION FLAME:. non-reacting & reacting laminar jet; Burke Schumann Flame: assumptions, simplification and solution of mass, species, momentum & energy equation with the boundary conditions; determination of temperature & mass-fraction distribution as well as flame height;
8. DROPLET EVAPORATION & COMBUSTION: assumptions, simplification and solution of mass, species & energy equation with the boundary conditions; determination of temperature & massfraction distribution, mass evaporation rate, flame stand-off ratio, flame temperature, expression for transfer numbers, evaporation/burning rate constant. droplet life-time etc.
9. SOLID COMBUSTION: Introduction to different features of solid combustion; One-film model: Twofilm model: Assumptions, simplification and solution of species & energy equation with the boundary conditions for the two models; determination of temperature & mass-fraction distribution, carbon burning rate, flame standoff ratio. flame temperature, expression for transfer numbers etc. for the two models.
10. INTRODUCTION TO ADVANCED PROBLEMS: Ignition; spray combustion; finite rate chemistry; fuel vapour accumulation; laminar/turbulent flow situations etc.

Course Outcomes (COs):	The students of the course should be able to – CO1: Describe thermodynamics related to combustion. CO2: Explain the fundamental principles of combustion. CO3: Apply laws and principles to simple combustion systems. CO4: Analyse real life combustion problems.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**1**													
CO2	**3**	**2**	**1**												
CO3	**2**	**3**	**1**												
CO4	**1**	**3**	**2**	**1**	**1**	**1**	**2**							**1**	

Course Code: ME(M2)/PE/B/T/325G	Course Name: Aerodynamics	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: Basic Professional Elective II	Nature of Course: Theoretical	

Course content/Syllabus:	Introduction: definition, vistas of aerodynamics, historical development. Kinematics of gas flow: equation of motion, circulation, Stoke's theory, stream function and velocity potential. Vortex motion: vortex tube, vortex sheet, Bio-Savart law, Kelvin's theorem, vortex theorems of Helmboltz. Combination of basic flow patterns: lift on a rotating cylinder, Magnus effect, Joukowski's transformation. Lift on an aerofoil: aerodynamic forces on a lifting surface; nomenclature and shape of aerofoils; lift and drag coefficients of aerofoils; circulation theory of lift; effect of wave on lift. Thin aerofoil theory and its application; finite span effects; induced drag. Drag on an aerofoil: effect of viscosity, skin friction and form drag; flow separation and stalling; boundary layer control and its effect. Effects of compressibility: Prandtl Glauert rule; shock waves on wings and bodies; effect of sweep on two dimensional wings. Application of the knowledge of aerodynamics in the design of turbomachine blades, streamlining vehicle structures, reducing wind-load on buildings and structures etc.
Course Outcomes (COs):	The students of the course should be able to: CO1: Describe the basic equations of aerodynamics. CO2: Develop the working equations for aerofoil from theories of potential flow and vortex motion. CO3: Explain the theory of thin aerofoils. CO4: Apply knowledge of aerodynamics to simple aerodynamic problems.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**1**													
CO2	**2**	**3**	**1**												
CO3	**3**	**1**													
CO4	**2**	**3**	**2**		**2**										
CO5	**2**	**2**	**3**		**2**								**1**		

Course Code: ME(M2)/PE/B/T/325H	Course Name: Advanced Production Processes	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: Basic Professional Elective II	Nature of Course: Theoretical	

Course content/Syllabus:	Basic principles of automation applied to drives and controls. Introduction to Numerical Control, Adaptive Control, Mechatronics. Unconventional machining processes – AJM, USM, ECM, CHM, EDM, EBM, LBM, PAM – Parameters, responses, mechanism and analysis, effect on material, applications, economics and selection of process; Hybridprocesses. Generative Manufacturing processes like stereolithography, SLS, and other processes. Introduction to Micro and Nano manufacturing

Course Outcomes (COs):	The students of the course should be able to: CO1: Classify different control systems applied to material removal machines. CO2: Describe the operation of different machines used in Non-Traditional Machining processes. CO3: Investigate mechanics controlling the responses of different Non-Traditional Machining processes. CO4: Outline the generative manufacturing processes. CO5: Outline the micro and nano manufacturing.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**1**													
CO2	**3**		**1**												
CO3			**2**	**3**											
CO4	**3**	**1**													
CO5	**3**	**1**													

Course Code: ME(M2)/PE/B/T/325I	Course Name: Quantity Production Methods	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: Basic Professional Elective II	Nature of Course: Theoretical	
Course content/Syllabus:	System of production, Inter-changeability of machine parts, Tolerances, fits and standardization, Measuring instruments for mass production and design of gauges, Machine tools for mass production, application of interchangeability in cutting practice. Jigs and fixtures, economic principles, principles of design, types of jigs and fixtures. Factors affecting mass tool products, different types of die, design principles of dies and punches. Plastic working of metal, forging, drop forging, bending, forming, embossing and drawing operations and die design principles, types of presses, accessories and attachments, selection of presses. Die-casting and moulding methods, products manufactured by die casting and plastic moulding, production by powder metallurgy. Relative cost of different production methods.	
Course Outcomes (COs):	The students of the course should be able to – CO1: Explain different production systems, the role of tolerances, fits and standardization in mass production CO2: Explain the use appropriate measuring instruments CO3: Design jigs and fixtures considering economic principles and design guidelines CO4: Apply principles of plastic working of metals, including forging, bending, and drawing operations CO5: Understand die-casting and molding methods for producing components	

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**														
CO2	**2**													**2**	
CO3	**3**	**2**	**2**											**2**	
CO4	**3**	**3**	**2**											**2**	
CO5	**2**														

Course Code: ME(M2)/PE/B/T/325J	Course Name: Laser Machining Process	
Credits: 3	Contact Hours/Week (L-T-P): 3-0-0	Full Marks: 100
Category of Course: Basic Professional Elective II	Nature of Course: Theoretical	

Course content/Syllabus:	Basic Laser principles: Light waves, EM spectrum, Wave and particle nature of light, polarized and unpolarised light, electron photons energy levels; Theory of laser: Population inversion, Spectrum vs emission and stimulated emission, Amplication gain, lasing conditions, pumping schemes, resonant cavity; Properties of laser light: Coherence monochromaticity, brightness, directivity; Output characteristics: Output modes, Beam diameters and divergence, CW beams, Pulsed beam, Ultra short pulses; Modified laser output: Wave length selectivity tuning, Non-linear wavelength changes, Raman shifting, Switches, Mode locking, Cavity dumping, Amplication. Types of Lasers: He-Ne laser, CO2, Argon – ion lasers, Nd- YAG laser, Excimer laser, Semiconductor laser and others. Fundamental of Optics: Geometrical Optics: Reflection, Refraction Lens, Focal length. Physical Optics: Diffraction, Polarisation, and Interference. Optical Components: High Power Optics, Laser Mirrors, Lens, Defects, Filters and coating, Reflective optics. Interaction of high power laser beams with materials: Material and laser parameters, Uniform condition, irradiance Model, Energy balance approximation, heating with melting, material removal, heating with vaporization, Keyhole welding; Laser machining system: Beam delivery system, Mirrors, Beam splitters, Focussing lens, Laser Head, Fibre optic coupling, Laser workstation. High power laser applications: Surface hardening, welding, cutting, drilling, marking and alloy cladding.
Course Outcomes (COs):	The students of the course should be able to – CO1: Explain the basic principles of lasers, including the nature of light waves, electron photon energy levels, population inversion, and lasing conditions CO2: Assess the properties of laser light and various output characteristics CO3: Apply knowledge of different laser types and optics CO4: Describe the interaction of high-power laser beams with materials CO5: Design laser machining system
CO-PO Mapping:	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**														
CO2	**3**	**1**													
CO3	**3**	**2**	**1**											**2**	
CO4	**2**														
CO5	**3**	**3**	**3**											**3**	

4th Year 1st Semester: Honours Professional Elective I

Course Code: ME(M2)/PE/H/T/414A	Course Name: Finite Element Method For Nonstructural Applications	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective I	Nature of Course: Theoretical	
Course content/Syllabus:	Review of variational calculus, Rayleigh Ritz method. Classification of problems governed by linear second order partial differential equations, linear self-adjoint operators, obtaining functional from differential equation for simple one-dimensional cases, Method of weighted residuals, One-dimensional problems of elasticity, heat conduction and fluid flow. General field problems, equilibrium problems – quasi-harmonic equations, finite element equations using variational principle and weighted residual techniques, examples from heat transfer, two dimensional fluid flow, two dimensional electric and magnetic fields, torsion etc. Eigenvalue problems – Helmholtz equation, finite element equations using variational principle and weighted residual techniques, examples from one-dimensional elasticity and wave equation. Propagation problems – time dependent field problems, finite element equations, transient response using mode superposition and time-integration. Use of commercial packages for solution of heat transfer, fluid flow and electric and magnetic field problems.	

Course Outcomes (COs):	The students of the course should be able to: CO1: Construct finite element equations for non-structural problems from governing differential equations using variational calculus and weighted residual method. CO2: Apply finite element method to solve the equilibrium equations (in one and two dimensions) of nonstructural problems. CO3: Construct the finite element equations for eigenvalue problems for non-structural applications. CO4: Solve propagation problems in non-structural applications using finite element method.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**3**													
CO2	**3**	**2**		**2**										**1**	
CO3	**3**	**2**													
CO4	**3**	**3**	**2**	**2**	**3**									**2**	

Course Code: ME(M2)/PE/H/T/414B	Course Name: Theory Of Pressure Vessels	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective I	Nature of Course: Theoretical	
Course content/Syllabus:	Introduction to pressure vessels- Fired and unfired vessels. [2] Vessel Mechanics – Thick and thin cylindrical vessel, Thick & Thin Spherical vessel, Analysis with the help of various failure theories. [6] Design of cylindrical & spherical vessel, heads (hemispherical, torispherical, elliptical, conical, flat) with the help of ASME equation. [5] Design of thin cylindrical vessel under external pressure. [2] Thermal Analysis of Cylindrical vessels, and Spherical vessel. [5] Autofrettage analysis of thin and thick cylindrical vessel [7] Design of vessel supports (e.g saddle, skirt, leg, lug) [8] Material specification- Material under low temperature services, high temperature services and corrosive services. Discussion on Indian standard of materials. [4] Introduction to fabrication, Testing and Maintenance [3]	
Course Outcomes (COs):	The students of the course should be able to – CO1: Analyze thick and thin cylindrical and spherical vessels using various failure theories. CO2: Design cylindrical and spherical vessels, including the selection and application of different head types, utilizing ASME codes. CO3: Conduct thermal analysis and autofrettage analysis of cylindrical and spherical vessels to assess their performance under thermal stress. CO4: Design vessel support systems such as saddles, skirts, legs, and lugs, considering structural stability and load distribution.	

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**	**2**											**2**	
CO2	**3**	**3**	**3**	**1**			**3**							**2**	
CO3	**3**	**2**	**2**											**2**	
CO4	**3**	**3**	**2**	**2**										**2**	

Course Code: ME(M2)/PE/H/T/414C	Course Name: Plastics, Polymers, Composites And Ceramics Materials	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective I	Nature of Course: Theoretical	

Course content/Syllabus:	Plastics and Polymers: Introduction, structure of plastics, polymer materials, plastics available to the designer, selection of plastics. General properties of plastics and polymers. visco-elastic behavior of plastics, short term testing of plastics, long term testing of plastics, design methods for plastics using deformation data, mathematical models of visco-elastic behavior, intermittent loading, deformation behavior of reinforced plastic. (10 pds) Composite Materials: Introduction and Classification; Strengthening mechanisms, Mechanics of composite materials; Definition of fibre reinforced composite materials with examples, benefits properties and applications. Polymer Matrix Composites: Polymer Matrices, Processing Techniques, Glass Reinforced Composite, Carbon Fiber Composites; Metal Matrix Composites: Metal Matrices, Processing Techniques, Interfacial Controls, Discontinuously Reinforced Composites, Fiber Composites; Fabrication processes. Rules of mixtures, Halpin-Tsai equations for effective moduli of a continuous fibre-reinforced lamina. Stress-strain relationship of a continuous fibre-reinforced lamina; Theories of failure for continuous fibre-reinforced lamina: maximum stress, maximum strain, Tsai-Hill and Tsai-Wu criteria;
	Mechanical testing of composites. Analysis of composite laminates with classical lamination theory. (22 pds) Ceramics Materials: Introduction; Ceramic Raw Materials, Ceramic Matrix Composites: Ceramic Matrices, Processing Techniques, Alumina Matrix Composites, Glass Matrix Composites; Crystal Structure and defects; Structure of glasses; Phase diagrams and phase transformation; Colloidal Properties:-Particle size and shape, Surface properties, Flocculation and Deflocculation, Rheology, Drain Casting & Solid Casting, Tape Casting, Forming Processes: Binders, Packing, Formation, Mechanics, Extrusion, Pressing, Injection Molding, Drying; Applications. (10 pds)
Course Outcomes (COs):	The students of the course should be able to – CO1: Explain the Structure and Properties of Plastics and Polymers. CO2: Describe the Visco-Elastic Behavior and Testing Methods of Plastics. CO3: Understand Composite Materials and Their Strengthening Mechanisms. CO4: Understand the fundamentals of Polymer Matrix and Metal Matrix Composites. CO5: Appreciate the intricacies associated with Mechanical Testing and Failure Analysis of Composites. CO6: Corelate the structure and properties of engineering Ceramic Materials.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**													
CO2	**2**	**2**											**2**		
CO3	**3**	**2**					**2**								
CO4	**3**		**2**				**2**								**1**
CO5	**2**	**3**	**3**	**2**									**2**		
CO6	**3**	**2**													

Course Code: ME(M2)/PE/H/T/414D	Course Name: Advanced Heat Transfer	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective I	Nature of Course: Theoretical	

Course content/Syllabus:	**Conduction Heat Transfer:** One dimensional energy equations and boundary condition, threedimensional heat conduction equations, heat conduction equations in different coordinate systems. Orthogonal curvilinear coordinates. Heat conduction equation for anisotropic materials. Non-Fourier heat transfer. Single and dual phase lag models. Extended surface heat transfer for multidimensional heat conduction and variable thermo-physical properties. Partial lumping systems. Conduction with moving boundaries. Separation of variables. Analytical methods in non-linear heat conduction problems. Introduction to heat transfer in human bodies. 13**Hours** **Radiation Heat Transfer:** Radiation in gases and vapour. Gas radiation and radiation heat transfer in enclosures containing absorbing and emitting media – interaction of radiation with conduction and convection. 5**Hours** **Turbulent Forced Convective Heat Transfer:** Momentum and energy equations, turbulent boundary layer heat transfer, mixing length concept, Turbulent Prandtl number. Turbulence model – K- Є model, analogy between heat and momentum transfer –Reynolds, Colburn, Prandtl turbulent flow in a tube, high speed flows. 7**Hours** **Phase Change:** Boiling: Pool boiling, Boiling regimes and the boiling curve, Heat transfer correlations in pool boiling, Film boiling, Scale analysis, Flow boiling. **Condensation:** Physical Mechanisms, Laminar film on a vertical Surface, Heat transfer correlations for film condensation. 9**Hours** **Numerical Methods in Heat Transfer:** Finite difference formulation of steady and transient heat conduction problems –Discretization schemes – explicit, Crank Nicolson and fully implicit schemes, control volume formulation, steady one dimensional convection and diffusion problems. Stability and consistency of numerical methods. Solution of simultaneous algebraic equations. Tri-Diagonal-Matrix Algorithm (Thomas Algorithm), Gauss-Siedel and Gauss-Jordon Methods. 8**Hours**
Course Outcomes (COs):	The students of the course should be able to – CO1: Solve heat conduction equations for simple geometries applying appropriate boundary conditions. CO2: Analyze heat conduction in anisotropic materials and non-Fourier heat transfer models. CO3: Assess radiation heat transfer in enclosures with absorbing and emitting media. CO4: Analyze phase change heat transfer.
CO-PO Mapping:	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**	**2**	**1**										**2**	
CO2	**3**	**3**	**2**	**1**										**2**	
CO3	**3**	**3**	**2**											**2**	
CO4	**3**	**3**	**2**											**2**	

Course Code: ME(M2)/PE/H/T/414E	Course Name: Steam Turbine	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective I	Nature of Course: Theoretical	
Course content/Syllabus:	Ideal and actual expansion of steam through nozzle, critical pressure ratio, maximum rate of discharge, under expansion and over expansion in nozzle. Nozzle efficiency & velocity coefficient of nozzles. Supersaturated flow through nozzle. 4**Hours**	
	Flow through simple impulse turbine blading, velocity diagram, blade efficiency, Gross stage efficiency, net stage efficiency, optimum velocity ratio. Degree of admission. 3**Hours** Multistaging or compounding of impulse turbine, velocity compounding, pressure compounding, velocity and pressure compounding . 6**Hours** Reheat factor, internal efficiency, state point locus etc. in relation to steam turbine. 4**Hours** Flow through Reaction turbine, velocity diagram, Degree of reaction, blade height, stage efficiency, optimum velocity ratio, axial thrust in reaction turbine. 4**Hours** Comparisons of impulse & reaction turbine, Losses in turbines, Partial admission loss, gland leakage loss etc. 3**Hours** Blades in turbine: Material, manufacturing, labyrinth packing, fixing and cooling, Erosion of turbine blades, turning gear, barring gear. 6**Hours** Turbine bearing and lubrication, Principle of turbine governing. 6**Hours** Constructional details and description of steam turbine components in brief, KWU set, LMW set with stages. 6**Hours**	

Course Outcomes (COs):	The students of the course should be able to – CO1: Demonstrate proficiency in analyzing steam expansion through nozzles, including critical pressure ratios, discharge rates, and efficiency parameters. CO2: Understand the principles of impulse and reaction turbines, including flow characteristics, velocity diagrams, degree of reaction, blade efficiencies, CO3: Analyze multistaging and compounding techniques in steam turbines CO4: Evaluate design aspects of turbine blades, including materials, manufacturing processes, cooling methods, and erosion prevention techniques. CO5: Explore turbine components, bearing systems, lubrication methods, governing principles of steam turbines.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**3**	**2**											**2**	
CO2	**3**														
CO3	**3**	**3**	**2**											**1**	
CO4	**3**	**3**	**3**	**1**										**2**	
CO5	**2**														

Course Code: ME(M2)/PE/H/T/414F	Course Name: Advanced Automotive Engines	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective I	Nature of Course: Theoretical	

Course content/Syllabus:	Problems of carburetor based engines (1 Period) Injection systems in SI engines, Basic Classifications like throttle body injection, Port fuel injection and direct injection systems, Their advantages and disadvantages (2 Periods) Fuel injector system, shape of the input pulse and necessity for control of the pulse width. Calculation of basic injection time and necessity of subsequent correction factors, Numerical problems (3 Periods) Introduction to engine control unit (ECU); Generation of the control signal for operation of fuel injection system in SI engines (2 Periods) Problems associated with conventional spark ignition circuit. Introduction to Transistorized ignition system, Study of the different methods of generation of input signals, its subsequent processing and the detail role of EeU (8 to 10 periods) Generation of pollutants and Pollution control systems; Measurement of pollutants; oxygen lambda senor and feed back control in PFI engines. (12 Periods) Intake and exhaust systems; Helmholtz resonator, inertial charging and wave charging in engines, brief introduction to earn-less engines and variable valve lift technology, numerical problems (8 periods) Introduction to turbulence; its generation and decay; Special flow problems in combustion chambers of modern SI engines. (4 Periods)
Course Outcomes (COs):	The students of the course should be able to – CO1: Analyze the limitations and issues associated with carburetor-based engines CO2: Compare injection systems in SI engines and evaluate their advantages, disadvantages, and applications. CO3: Analyze fuel injector systems, including the shape and control of input pulses. CO4: Explore conventional spark ignition circuits and the associated challenges. CO5: Comprehend the generation of pollutants in SI engines and the role of pollution control systems. CO6: Understand the generation of turbulence and its impact in combustion chambers of modern SI engines.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**	**2**													
CO2	**2**	**1**												**1**	
CO3	**3**	**2**												**2**	
CO4	**3**	**2**												**2**	
CO5	**3**	**3**					**3**							**2**	**2**
CO6	**2**	**2**													

Course Code: ME(M2)/PE/H/T/414G	Course Name: Introduction To Turbulent Fluid Flow

Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective I	Nature of Course: Theoretical	

Course content/Syllabus:	Introduction to turbulent flow, Characteristics of turbulent flow, Laminar turbulent transition, Origin of Turbulence, Wall bounded Turbulence and free turbulence. (4 Hours) Classification of Turbulence, Isotropic and anisotropic Turbulence, Time Mean motion and Fluctuations, Length scales, velocity Scales, Time scales and Kolmogorov scales, Intensity of Turbulence and Degree of Turbulence. (4 Hours) The Governing equations of Turbulent flow, The N-S equations in Rectangular and Cylindrical Coordinates, Time averaging of the N-S equations, Reynolds Stresses, Significance of Reynolds stress, The concept of Eddy Viscosity. (8 Hours) Turbulent Boundary-Layer equations, concept of Order of magnitude and it's application to Boundary layer equations on a flat plate, Boundary conditions, Laminar sub-layer, Universal Velocity profile on a flat plate, rectangular duct and circular pipes and friction factors. (8 Hours) The concept of vorticity dynamics, Energy producing Large eddies and dissipative eddies, vortex stretching, Concept of energy cascading, Kolmogorov Energy spectrum. (4 Hours) Developing and Fully Developed Turbulent Flow in a pipe for Moderate Reynolds Number, variation of friction factors and shear stresses. (2 Hours) Shear stress models, Prandtl's Mixing length Hypothesis, The eddy viscosity model, The two equation model, The wall function conception, Solution methodology of model. (10 Hours)
Course Outcomes (COs):	The students of the course should be able to: CO1: Associate concepts from Fluid Mechanics to turbulent transport phenomena. CO2: Compute turbulence parameters for different flow configurations. CO3: Construct theoretical models for simple engineering problems. CO4: Analyze complex transport phenomena involving turbulence.
CO-PO Mapping:	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1													
CO2	2	3	1												
CO3	3	2	2		1										
CO4	2	3	2	1	2										

Course Code: ME(M2)/PE/H/T/414H	Course Name: Theory Of Metal Forming	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective I	Nature of Course: Theoretical	

Course content/Syllabus:	Introduction; Structure of metals; Stress and strain analysis; Fundamentals of plastic deformation; Basic theory of plasticity, yield criteria of metals; determination of working load in plastic deformation. Introduction to metal forming; methods of solution of forming problems; Mechanics of metal forming processes, e.g. rolling, forging, drawing, extrusion, bending etc. Friction and lubrication in metal forming processes; Defects in metal working.
Course Outcomes (COs):	The students of the course should be able to: CO 1: Explain theory of plasticity, yield criteria and calculate working load in plastic deformation. CO 2: Demonstrate mechanics of various metal forming processes. CO 3: Understand effects of friction and lubrication in metal forming and identify defects in metal working.
CO-PO Mapping:	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2			2										
CO2	3	2	2											2	
CO3	2					2									

Course Code: ME(M2)/PE/H/T/414I	Course Name: Production Systems And Controls	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective I	Nature of Course: Theoretical	

Course content/Syllabus:	Introduction: Production and production system; Models of production systems, planning, analysis and control of production systems, production control information system; Integrated production control systems. Forecasting: Long and short term forecasting methods; time-series prediction; growth analysis by exponential smoothing; Forecast error analysis; the Box-Jenkins approach; Delphi Technique. Aggregate planning and master scheduling: Different approaches to aggregate planning; parametric approach to production planning; optimization approaches to aggregate planning; Desegregation to a master schedule. Sequence and scheduling: Sequencing tasks on processors; Job-shop scheduling; The line balancing problem; Line balance; project scheduling by network techniques; scheduling with resource constraints;
	Manpower Planning and Behavioral Science; Control and Reliability of Production Systems: Quality assurance; Inspection and acceptance sampling; control charts; system reliability. Case study.
Course Outcomes (COs):	The students of the course should be able to: CO1: Understand different models of production systems, including planning, analysis, and control mechanisms. CO2: Apply forecasting techniques like the Box-Jenkins approach and Delphi Technique. CO3: Comprehend various approaches to aggregate planning, including parametric and optimization methods. CO4: Apply sequencing and scheduling techniques to optimize production processes, including job-shop scheduling and line balancing.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1													
CO2	3	3									1			1	
CO3	2	2		1											
CO4	2	2		1							2			1	

Course Code: ME(M2)/PE/H/T/414J	Course Name: Design of Thermal systems	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective I	Nature of Course: Theoretical	

Course content/Syllabus:	Introduction to Thermal System Design	(2)
	Basic Considerations in Design	(2)
	Mathematical Modeling of Thermal Systems	(6)
	Numerical Modeling and Simulation	(5)
	Thermal System Design from Thermodynamic Considerations	(4)
	System Simulation and System Identification	(5)
	Formulation for Optimal Design; Lagrange Multipliers; Search Methods	(4)
	Geometric, Dynamic and Linear Programming	(3)
	Introduction to use of soft computing in Thermal System Design and Optimization	(8)
Course Outcomes (COs):	The students of the course should be able to – CO1: Associate fundamental principles of thermodynamics, fluid mechanics and heat transfer for thermal systems. CO2: Apply different numerical techniques to practical thermal systems. CO3: Analyse thermal systems through mathematical modelling. CO4: Formulate design statements for practical thermal systems. CO5: Assess application of optimization techniques for thermal system design	

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2													
CO2	2	3	1												
CO3	1	3	2	2	2										
CO4	1	2	3	2	2		1							1	
CO5	2	1	1	3	2	1	1							2	

Course Code: ME(M2)/PE/H/T/414K	Course Name: Gas Turbines	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective I	Nature of Course: Theoretical	

Course content/Syllabus:	Ideal cycle analysis for gas turbine including the effects of perfect inter- cooling, ideal reheating and ideal heat exchanger. Comparison between ideal and actual cycles including effects of pressure drop in heat exchanger, isentropic efficiencies of compressor and turbine and changes in composition of working fluid (4 periods) Review of small stage efficiency and stagnation quantities (2 periods) Use of Gas turbines in air craft propulsion systems: Momentum thrust and pressure thrust; propulsion efficiency; analysis of subsonic and supersonic intakes, analysis of subsonic and supersonic exhaust nozzles, Analysis of turbo-jet, turbo-fan and turbo prop engines; introduction to Ram jet engines (10 periods) Centrifugal compressor, energy for compression, slip factor, power input factor, inlet pre-whirl, Mach number at the inlet of diffuser, Non-dimensional quantities and compressor characteristics; surge line and rotating stall. (8 periods) Axial flow compressor, energy for compression, work done factor, Degree of reaction, three dimensional flow, review of radial equilibrium theory and free vortex design, losses in compressor, blade nomenclature, axial flow compressor characteristics (8 periods) Gas turbine combustion chambers, types, pressure drop (4 periods) Axial flow turbines, work done per stage, flow coefficient, blade loading co- efficient and degree of reaction, nozzle loss co-efficient, free vortex design and constant nozzle angle design, characteristics (6 periods) Prediction of performance of gas turbine plant as a whole unit (2 periods)
Course Outcomes (COs):	The students of the course should be able to: CO1: Understand the basic thermodynamic gas cycles of gas turbine. CO2: Examine working principles and characteristics of different types of compressors and turbines. CO3: Describe the combustion mechanisms in gas turbine engine. CO4: Analyze the performance of gas turbine.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**														
CO2	**3**														
CO3	**3**	**2**													
CO4	**3**	**3**	**3**	**2**											

Course Code: ME(M2)/PE/H/T/414L	Course Name: Thermal Turbo Machines	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective I	Nature of Course: Theoretical	

Course content/Syllabus:	**Basic Concepts of Turbo Machines:** Classification of Turbo Machines, Basic Laws and Governing Equations, Efficiencies. (4hrs) **Blade Theory:** Aero-Foil Section, Drag and Lift, Cascade. (4hrs) **Centrifugal Compressors and Fans:** Components and Description, Velocity Diagrams, Slip Factor, Stage Pressure Rise and Loading Coefficient, Degree of Reaction, Diffuser, Centrifugal Compressor Characteristics. (6hrs) **Axial Flow Compressors and Fans:** Working Principle, Velocity Triangles for an Axial Flow Compressor Stage, Energy Transfer or Stage Work, Stage Loading (or) Pressure Coefficient, Reaction Ratio, Review of radial equilibrium theory and free vortex design, Axial flow compressor characteristics. (8hrs) **Axial Flow Steam and Gas Turbines:** Velocity Triangles for an Axial Flow Turbines, Stage Work and Diagram Efficiency, Stator (Nozzle) and Rotar Losses, Compounding (or) Staging, The Reaction Turbine, Stage Efficiency of Reaction Turbine, Impulse Turbines Versus Reaction Turbines. (10 hrs) **Radial Flow Gas and Steam Turbines:** Velocity Diagrams, Stage Efficiencies Velocity, Degree of Reaction, Triangles and Stage Work. (8hrs)

Course Outcomes (COs):	The students of the course should be able to - CO1: Demonstrate understanding of compressible flow turbomachines, including classification, types, and basic thermodynamic principles. CO2: Apply dimensional analysis techniques to evaluate performance parameters and efficiencies of turbomachine stages. CO3: Analyse stage velocity triangles and enthalpy-entropy diagrams to assess performance characteristics CO4: Develop design parameters to enhance performance and minimize losses in turbomachine stages. CO5: Evaluate effectiveness of different turbomachine configurations and design strategies in achieving desired performance objectives.
CO-PO Mapping:	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**3**													
CO2	**3**	**3**		**2**											
CO3	**3**	**3**		**2**											
CO4	**3**	**3**	**2**	**1**										**2**	
CO5	**2**	**2**	**1**	**1**										**1**	

4th Year 1st Semester: Honours Professional Elective II

Course Code: ME(M2)/PE/H/T/415A	Course Name: Elements Of Fracture Mechanics	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective II	Nature of Course: Theoretical	
Course content/Syllabus:	1. Background of the subject, review of stress, strain, deformation and failure. [4 classes] 2. Theoretical cohesive strength, Effect of discontinuity on fracture strength, Various sources of cracks, Griffith's criteria and its limitations, Orwan's correction. [4 classes] 3. Energy approach, strain energy release rate, critical strain energy release rate for fixed grip and fixed load conditions. [3 classes] 4. Stress approach, basic concepts of stress intensity factor, critical stress intensity factor, Geometry parameter Y, modes of fracture, simple problem on stress intensity factors, interrelation between stress approach and strain energy approach. [4 classes] 5. Crack tip plasticity models, fictitious crack length, plane stress versus plane strain, plane strain fracture toughness, problems associated with crack tip plasticity, R-curve behavior and crack arrest, toughening mechanisms: intrinsic and extrinsic. [6 classes] 6. Evolution of Fracture toughness evaluation, effect of geometry, temperature and strain rate on fracture behavior and on Ductile-brittle transition temperature, Relation between plane strain fracture toughness and CVN, Indentation method and other techniques to measure toughness. [6 classes] 7. Modes and models of fracture in metals: steps of micro-void formation and coalescence, ceramics and polymers. [4 classes]	
Course Outcomes (COs):	The students of the course should be able to – CO1: Describe basic concepts of Fracture Mechanics. CO2: Apply basic concepts of Linear Elastic Fracture Mechanics, Elasto-Plastic Fracture Mechanics to formulate and solve simple fracture mechanics problems. CO3: Relate structure and property of different materials in context of deformation and fracture. CO4: Analyse various mechanisms of time dependent fracture. CO5: Deduce the life cycle of engineering components using the basic concepts of fatigue. CO6: Identify the nature of fracture in the light of fractography.	
CO-PO Mapping:		

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**	**2**												
CO2		**3**	**3**												
CO3	**3**		**2**	**2**			**1**							**2**	
CO4	**3**		**2**				**2**							**2**	
CO5	**3**	**3**	**2**				**2**							**2**	
CO6	**2**	**3**		**2**									**2**	**2**	

Course Code: ME(M2)/PE/H/T/415B	Course Name: Design Methodology For Fracture, Fatigue And Creep

Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective II	Nature of Course: Theoretical	

Course content/Syllabus:

Review of Failure theories
Concept and significance of fracture mechanics theory (LEFM & EPFM).
Fracture parameters applicable in design
Fracture toughness testing
Computational Fracture Mechanics
KIc based design, CTOD design curve, ductility instability analyses, EPRI method, R6 method, practical considerations, Failure assessment diagram, Probabilistic Fracture mechanics.
Fatigue: Failure Mechanism, Design Methods: Stress based (S-N Curve), Strain based (strain - life), Crack growth (Paris law), Damage tolerant.
Creep: Failure mechanism, Creep curve, Design methods based on creep failure.

Course Outcomes (COs):

The students of the course should be able to –
CO1: Explain the concepts and significance of Linear Elastic Fracture Mechanics (LEFM) and ElasticPlastic Fracture Mechanics (EPFM)
CO2: Analyse concepts of computational fracture mechanics
CO3: Apply design methods based on stress, strain and crack growth to develop damage-tolerant designs
CO4: Evaluate creep failure mechanisms and design approaches

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2												2	
CO2	3	2												2	
CO3	3	3	3	2										2	
CO4	3	2	2	1										2	

Course Code: ME(M2)/PE/H/T/415C	Course Name: Dynamics Of Thermal Systems	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective II	Nature of Course: Theoretical	

Course content/Syllabus:

Introduction to Thermal Systems	2
Mathematical Modeling of Thermal Systems	4
Examples of Mathematical Models of Thermal Systems	4
State Space Models for Thermal Systems; Linearisation	2
Dynamic Simulation of Linear Thermal Systems	4
Stability Analysis of Fixed Points in State Space; Phase Plots	2
Bifurcation Analysis of Fixed Points	2
Stability of Limit Cycles; Floquet Theory; Monodromy Matrix; Poincare Map	3
Bifurcation Analysis of Limit Cycles	1
Lyapunov Exponents	2
Introduction to Chaos	1
Nonlinear Time Series Analysis; Time Delay Phase Plots; Embedding Dimension	3
Characterization of Time Delay Phase Plots; Lyapunov Exponents; Correlation Dimension; Kolmogorov Entropy; Recurrence Analysis	6
Case Studies: Examples of Chaotic Thermal Systems	3

Course Outcomes (COs):

The students of the course should be able to –
CO1: Develop mathematical models of thermal systems
CO2: Conduct dynamic simulations of linear thermal systems
CO3: Analyze the stability of systems using state space methods and phase plots
CO4: Apply nonlinear time series analysis techniques to thermal systems

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	1											
CO2	3	2	2	2			2							2	
CO3	3	2												1	
CO4	3	3	2	1										1	

Course Code: ME(M2)/PE/H/T/415D	Course Name: Steam Generators	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective II	Nature of Course: Theoretical	

Course content/Syllabus:

Layout of a typical pulverized coal fired power boiler plant. (2 Periods)

Natural circulation based boiler, analysis of closed loop hydrodynamic systems, driving head and useful head, hydraulic characteristics of closed circulation loops, determination of operating point of simple circuit, circulation stagnation and flow reversal, complex circuits and determination of their operating points, presence of steam in the down-comer and its effect on circulation, remedial measures.
(12 periods)

High pressure boilers, Types of cooling circuits in furnace region, typical layout of modern high pressure boilers. (6 periods)

Fluid dynamic aspects of straight flow and vortex flow burners, arrangement of burners in the furnace.
(8 periods)

Introduction to two phase flow; nucleate boiling, sub-cooled boiling, saturated boiling, flow patterns in a vertical tube under diabatic condition, critical heat flux and its implications. (10 periods)

Mineral matter content in coal, formation of ash, fouling and slagging. (4 periods)

Course Outcomes (COs):

The students of the course should be able to -

CO1: Describe steam generators, components, combustion process

CO2: Apply engineering concepts and principles on steam generator components

CO3: Analyse component and system performances

CO4: Formulate design and operation at subcomponent levels

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**														
CO2	**3**	**2**													
CO3	**3**	**3**												**2**	
CO4	**3**	**3**	**2**	**1**										**2**	

Course Code: ME(M2)/PE/H/T/415E	Course Name: Bio-Heat Transfer	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective II	Nature of Course: Theoretical	

Course content/Syllabus:

1. **Bioheat transfer and thermal heating for tumour treatment (10hrs)**

Background of Hyperthermia treatment

Pennes' and other bioheat transfer equations

Benefits of Hyperthermia over chemotherapy

2. **Development of non-Fourier bioheat models (10hrs)**

Importance of finite energy propagation in living tissues

Single-phase-lag (SPL) bioheat model

Dual-phase-lag (DPL) bioheat model

Essentiality of thermal relaxation time in thermal therapy

3. **Local thermal non-equilibrium (LTNE) approach in bioheat transfer (8hrs)**

Comparison of LTNE and LTE modelling

Selection of porous media (Volume average theory) in energy equations of bioheat transfer

Formulation of governing differential equation based on LTNE approach Impact of relaxation time lags on LTNE modelling

4. **Multi-layered modelling bioheat transfer (8hrs)**

Selection of different skin layers of tissue

The Composite Bioheat Problem

Influence of external heat flux on multi-layered tissue

Development of analytical and numerical solution of thermal response in tissues

5. **Quantitative Models of Thermal Damage to Cells and Tissues (5hrs)**

Reaction Rates and Temperature

Thermal Denaturation of Proteins

Selection of statistical models for prediction of thermal damage

Course Outcomes (COs):	The students of the course should be able to – CO1: Describe the concept of bioheat transfer. CO2: Develop models for bioheat transfer. CO3: Assess local thermal non-equilibrium (LTNE) approach in bioheat transfer. CO4: Appraise multi-layered modelling of bioheat transfer. CO5: Apply quantitative models to determine thermal damage to cells and tissues.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**		**1**	**1**		**1**						**1**			
CO2	**3**	**2**	**1**	**1**								**1**			
CO3	**3**	**1**	**1**									**1**			
CO4	**3**	**2**	**1**	**1**								**1**			
CO5	**3**	**2**	**1**	**1**		**1**						**1**			

Course Code: ME(M2)/PE/H/T/415F	Course Name: Hydro, Wind And Wave Power	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective II	Nature of Course: Theoretical	
Course content/Syllabus:	Hydropower – hydropower potential in India and in the world. Water power estimate from stream flow data, hydrographs, mass curve; water ways - canal and penstock; general arrangement of hydropower station; water hammer surge tanks; water turbines – determination of important dimension - selection, performance, governing; cavitation model. Tidal power plant – estimation of power, types of turbine – operational characteristics; pump-storage-plant –economic consideration, single machine acting as pump and turbine. Atmospheric circulation: wind speed variation and flow patterns; estimation of wind energy, energy conversion methods – windmill, air turbines. Energy balance of the environment and ocean; tidal waves and ocean currents, tidal cycles; harnessing tidal and ocean energy; low head water turbines.	
Course Outcomes (COs):	The students of the course should be able to: CO1: Describe scope of nonconventional energy potential. CO2: Explain the basic principles of hydro, wind and wave power and conversion methodologies. CO3: Compute power from hydro, wind and wave power systems. CO4: Apply the basic principles of power generation in solutions comprising of necessary components of different systems.	

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**					**1**	**3**								
CO2	**3**	**2**													
CO3	**2**	**3**	**1**												
CO4	**2**	**2**	**3**												

Course Code: ME(M2)/PE/H/T/415G	Course Name: Total Quality Management And Six Sigma	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective II	Nature of Course: Theoretical	

Course content/Syllabus:	**Introduction** Introduction, Need for quality, Evolution of quality, Definitions of quality, Dimensions of product and service quality, Basic concepts of TQM, TQM Framework, Contributions of Deming, Juran and Crosby, Barriers to TQM, Quality statements, Customer focus, Customer orientation, Customer satisfaction, Customer complaints, and Customer retention, Costs of quality **TQM Principles** Leadership, Strategic quality planning, Quality Councils, Employee involvement, Motivation, Empowerment, Team and Teamwork, Quality circles Recognition and Reward, Performance appraisal, Continuous process improvement - PDCA cycle, 5S, Kaizen, Supplier partnership - Partnering, Supplier selection, Supplier Rating **TQM Tools & Techniques I** The seven traditional tools of quality, New management tools, Six sigma: Concepts, Methodology, applications to manufacturing, service sector including IT, Bench marking, Reason to bench mark, Bench marking process, FMEA, Stages, Types **TQM Tools & Techniques II** Control Charts, Process Capability, Concepts of Six Sigma, Quality Function Development (QFD), Taguchi quality loss function, TPM, Concepts, improvement needs, Performance measures **Quality Systems** Need for ISO 9000, ISO 9001-2008, Quality System - Elements, Documentation, Quality Auditing - QS 9000 - ISO 14000 - Concepts, Requirements and Benefits – TQM Implementation in manufacturing and service sectors
Course Outcomes (COs):	The students of the course should be able to – CO1: Describe Quality as key to surviving tough competition. CO2: Introduce quality control and total quality system. CO3: Illustrate quality philosophies of leading experts. CO4: Discuss quality management practices, tools and standards including ISO 9000 standards
CO-PO Mapping:	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**					**2**									**1**
CO2	**3**	**3**									**3**			**1**	**1**
CO3	**3**										**2**				
CO4	**3**	**2**									**2**			**2**	

4th Year 1st Semester: Honours Professional Elective III (Not Specialization Specific)

Course Code: ME(M2)/PE/H/T/416A	Course Name: Mathematical Methods in Mechanical Engineering	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective III	Nature of Course: Theoretical	
Course content/Syllabus:	**Module 1**: Eigen value and vectors of a matrix and its application in problems of principal stress/strain; in 3-d stress distribution, mass moment of inertia of rigid bodies **Module 2**: Multiple integrals (double and triple) and its application in finding mass moment of inertia of rigid bodies; area moment of inertia of 3-d shell elements **Module 3**: Vector calculus: divergence, curl, grad and its application in engineering problems **Module 4**: Fourier series, Laplace transformations etc and its application in engineering problems **Module 5**: Probability distributions, hypothesis testing, and its application in engineering problems **Module 6**: Simple linear regression and correlation, least square methods, test of significance, prediction and residual analysis, ANOVA, and its application **Module 7**: Multiple regression, matrix approach and multicollinearity, and its application in engineering problems **Module 8**: Multivariate analysis, PCA and FA, and its application in engineering problems	

Course Outcomes (COs):

The students of the course should be able to –

CO1: Solve 3D stress distribution, principal stress/strain, mass moment of inertia etc. through Eigen value analysis.

CO2: Compute moment of inertia of rigid bodies and shell elements by employing multiple integrals. CO3: Apply concepts of vector calculus, Fourier series and Laplace transformations to engineering problems.

CO4: Understand probability distributions and hypothesis testing in the context of application to engineering problems.

CO5: Illustrate the concepts and application of simple regression and correlation, least square method, ANOVA and multiple regression.

CO6: Employ multivariate analysis in solving engineering problems.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2									1			
CO2	3	2	2									1			
CO3	3	3	2									1			
CO4	3	3	2	1								1			
CO5	3	3	2									1			
CO6	3	2	2	1								1			

Course Code: ME(M2)/PE/H/T/416B	Course Name: Hybrid and Electric Vehicles	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective III	Nature of Course: Theoretical	

Course content/Syllabus:

Part 1 [29 Hours]

1. Review of Internal Combustion Engines, conventional vehicles, issues and challenges, Importance of alternative vehicles and fuels. [5 hours]
2. Fundamentals of Vehicle Propulsion and Braking, Vehicle Transmission, Components – gears, differential, clutch, brakes etc. [10 Hours]
3. Electric vehicles [EVs]: Introduction, Components, layout, vehicle mechanics – Roadway fundamentals, vehicle kinetics, Dynamics of vehicle motion - Propulsion System Design. [5 Hours]
4. Hybrid Electric Vehicles [HEVs]: Introduction, types – series, parallel and series, parallel configuration – Design – Drive train, sizing of components. [4 Hours]
5. Batteries: Basics – Types, Parameters – Capacity, Rating, Discharge rate, State of charge, state of Discharge, Depth of Discharge, Technical characteristics, Properties of Batteries [5 Hours] **Part 2 [23 Hours]**
6. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Electric drives used in HEV/EVs, their classifications and general characteristics. DC Motor drives and their principle of operation and performance, Induction motors, their configurations and optimization for HEV/EVs, Induction motor drives, their control and applications in EV/HEVs., Permanent magnet motors, their configurations and optimization, Permanent magnet motor drives, their control and applications in EV/HEVs, Switch reluctance motors, their configurations and optimization, Switch reluctance motor drives, their control and applications in EV/HEVs. [10 Hours]
7. Fuel Cells: Fundamentals, components, types, uses in automobiles, issues and challenges. [4 Hours]
8. Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. [5 hours]
9. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems [4 Hours]

Course Outcomes (COs):

The students of the course should be able to -

CO1: Define fundamental of vehicle propulsion and electric vehicles.

CO2: Define basic of hybrid electric vehicles and batteries.

CO3: Apply the concepts to understand electric propulsion unit.

CO4: Define the fundamental of fuel cells, energy storage and drive system.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1													

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO2	**2**	**3**	**1**												
CO3	**2**	**3**	**2**											**1**	
CO4	**1**	**2**	**3**	**2**										**2**	

Course Code: ME(M2)/PE/H/T/416C	Course Name: Continum Mechanics	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective III	Nature of Course: Theoretical	

Course content/Syllabus:

1. Introduction to Vector space and Tensors.
2. Kinematics-Lagrangian and Eulerian descriptions. Strain tensors. rate of deformation.
3. Balance Laws- Transport theorems, Conservation of mass, LMB and AMB. Cauchy's stress tensor.
4. Linear(ized) Elasticity: Torsion, Bending, Pressure vessels etc.
5. Frame indifference.
6. Introduction to Hyperelasticity and other material nonlinearities.
7. Fluid Mechanics- Hydrostatics, Ideal flow, Laminar Boundary layer.
8. Basic Thermodynamics.

Course Outcomes (COs):

The students of the course should be able to –

CO1: Comprehend the concepts of Lagrangian and Eulerian measures of strains.

CO2: Apply the concepts of balance laws, stress measures.

CO3: Understand the fundamentals of linear elasticity.

CO4: Apply the concepts of continuum mechanics in the context of material nonlinearities.

CO5: Apply the fundamentals in the field of non-structural physics.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**													
CO2	**2**	**2**													
CO3	**3**														
CO4	**3**	**2**	**2**											**1**	
CO5	**3**	**2**	**2**											**1**	

Course Code: ME(M2)/PE/H/T/416D	Course Name: Mechatronics	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective III	Nature of Course: Theoretical	

Course content/Syllabus:

Integration of electromechanical systems, mechanical structure, sensor, actuator, computer monitoring, control. Modelling of sensor, strain, force, position, velocity, acceleration etc, measurement, review of earlier concepts. Modelling of actuator, magnetic actuator, piezoelectric actuator, D.C. motor, stepper motor etc. Computer interfacing of sensor and actuator, power amplifier and actuator devices. Modelling and simulation of mixed dynamic system. Data acquisition and virtual instrumentation using MATLAB, NI/DSPACE or other equivalent packages. Real time Monitoring and control using PC based and embedded microcontrollers. Laboratory experiments.

Course Outcomes (COs):

The students of the course should be able to –

CO1: Develop models of electromechanical systems with sensors and actuators.

CO2: Discuss the principle of measurement of various physical quantities.

CO3: Discuss principles of operation of a few specific actuators.

CO4: Discuss simulation and implementation of real-life systems.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**3**	**2**											**2**	
CO2	**2**														
CO3	**2**														
CO4	**3**	**2**	**2**	**1**										**3**	

Course Code: ME(M2)/PE/H/T/416E	Course Name: Sustainable Engineering	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective III	Nature of Course: Theoretical	

Course content/Syllabus:	**Preamble:** Global resources and its classification. Human well-being and its interdependence with the global and local resources and eco systems. **Technology and industry:** Industrial revolution and progress of human civilization. Economic growth. Human comfort. Improved living standards. Resource consumption. Waste generation. Environmental degradation. Local and global impacts. Long term vulnerability. **Sustainable development:** Background and concept development. Pillars of sustainability. Global and local issues of sustainable development. Conflicting interests and challenges. **Reasons of unsustainability:** Economics and the environment; business and the environment; engineering and the environment; society (including politics), injustice and the environment. **Sustainability/unsustainability assessment:** Challenges and limitations. Different footprints assessments. Material and energy flows. Exergy and Energy analysis. Life cycle impact assessment. Need for planning for long term sustainability. Need for sustainable engineering. **Future pathway for sustainability:** concept of sustainable design of processes and products; ecosystem and engineering; circular economy and industrial symbiosis; techno-economics-ecology studies; policies and regulations towards better sustainability; corporate and social responsibility; social awareness and acceptability; multi-criteria optimization for sustainable path determination A few case studies with suitable examples.
Course Outcomes (COs):	The students of the course will be able to - CO1: Recall limitations of conventional engineering CO2: Understand the concept and relevance of sustainable development CO3: Analyze unsustainability of conventional engineering CO4: Apply the knowledge for better sustainable products and services

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**														
CO2	**2**					**2**	**3**							**2**	
CO3	**2**	**2**				**2**	**2**							**2**	
CO4	**2**	**2**	**1**			**2**	**2**							**2**	

Course Code: ME(M2)/PE/H/T/416F	Course Name: Atmospheric Fluid Dynamics	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective III	Nature of Course: Theoretical	

Course content/Syllabus:	General structure of the atmosphere; elements of meteorology - lapse rate of temperature, temperature inversions, isotherms & isobars. Atmospheric circulation, vertical convection, centrifugal effects, stability of the atmosphere. Effect of earth's rotation, effect of friction. Atmospheric motions; wind scales. Atmospheric boundary layer, governing equations; Ekman spiral; logarithmic and power laws; atmospheric turbulence. Effect of wind on smoke dispersion; determination of chimney height. Basic similarity requirements; dimensional analysis; basic scaling considerations; wind tunnel simulations of atmospheric flows; wind tunnel testing.
Course Outcomes (COs):	The students of the course should be able to: CO1: Describe the general structure and elements of atmosphere and meteorology CO2: Analyze the concept and effects of atmospheric boundary layer CO3: Analyze the effects of wind on smoke dispersion and air pollution CO4: Identify the non-dimensional parameters describing atmospheric flows through similarity analysis

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**					**2**	**2**								
CO2	**3**	**2**												**1**	
CO3	**3**					**2**	**2**							**1**	
CO4	**3**	**2**													

Course Code: ME(M2)/PE/H/T/416G	Course Name: Reliability in Engineering Design	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective III	Nature of Course: Theoretical	

Course content/Syllabus:	Basic concept of reliability, Importance of reliability in design, Introduction to mathematical statistic and statistical distribution theorem. Bath Tub Curve. Reliability measures: Reliability function, Reliability model (exponential, normal, Weibul…), Hazard model and product life, estimation of hazard function. Static reliability models: series, parallel, combined…. Probabilistic design: methodology, strength stress distribution, reliability and safety factors, reliability bounds in design. Design failure mode and criticality analysis Accelerated life testing Combination of random variables, Interference theory and reliability computation for various types of statistical stress and strength distribution. Reliability design examples Time dependent reliability models addressing damage, cyclic damage. Reliability estimation for exponential and Weibul distribution. Reliability allocation, reliability optimization in design. Prognostics health management and health monitoring.
Course Outcomes (COs):	The students of the course should be able to: CO1: Grasp the fundamental principles of reliability, including definitions, metrics and the significance of reliability in engineering design CO2: Apply mathematical statistics and probability theory to model and analyze reliability in engineering design. CO3: Develop skills in designing and evaluating reliable systems, employing techniques such as probabilistic design methodologies, reliability allocation and safety factors analysis. CO4: Implement advanced reliability techniques.

CO-PO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**													**2**	
CO2	**3**	**2**	**2**	**1**											
CO3	**3**	**3**	**2**	**2**		**2**								**2**	
CO4	**3**	**1**												**2**	

Course Code: ME(M2)/PE/H/T/416H	Course Name: Experimental Methods and Data analysis	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective III	Nature of Course: Theoretical	

Course content/Syllabus:	**Introduction:** Strategy of experimentation, Principles and guidelines for designing experiments, Experimental data acquisition techniques **Analysis of Experimental Data:** General considerations in data analysis, Causes and types of experimental errors, Error analysis, Uncertainty analysis and propagation of uncertainty, Test of goodness of fit **Basic Statistical Methods for Data Analysis:** Probability distributions, Sampling and sampling distributions, Testing of hypothesis, Analysis of variance **Design of Experiments:** Factorial experiments, Two-level factorial designs, Two-level fractional factorial designs, Factorial designs with higher levels, Blocking and confounding of factorial designs, Randomized block design and other experimental designs, Robust design and orthogonal arrays **Regression Analysis and Response Surface Methodology** Modeling using multiple regression, Hypothesis testing and confidence interval estimation in multiple regression, Testing of lack of fit Modeling using response surface method, Method of steepest ascent, First order and second order models, Experimental design for fitting response surfaces
Course Outcomes (COs):	The students of the course should be able to – CO1: Apply principles and guidelines for designing experiments with appropriate data acquisition techniques to achieve reliable results CO2: Conduct error and uncertainty analysis CO3: Utilize probability distributions, sampling methods, hypothesis testing and analysis of variance to analyze experimental data to draw valid conclusions CO4: Utilize advanced experimental design and regression techniques

CO-PO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**2**													
CO2	**3**	**3**													
CO3	**3**	**2**		**2**										**2**	

CO4	**3**	**2**		**2**	**2**									**2**	

4th Year 2nd Semester: Honours Professional Elective IV

Course Code: ME(M2)/PE/H/T/424A	Course Name: Finite Elements For Dynamics And Non-Linearity	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective IV	Nature of Course: Theoretical	
Course content/Syllabus:	Dynamic problems in elasticity, derivation of mass matrix using virtual work method and Hamilton's principle, truss, beam and isoparametric elements, a discussion on computation of eigenvalues and eigenvectors, harmonic and non harmonic response, transient response using central difference, Newmark techniques and mode superposition. Introduction to the solution of random vibration problems. Component mode synthesis. Solution of simple problems using commercial finite element package. Non-linearity – an introduction. Material nonlinearity –introduction to plasticity, formulation for small strain, computational procedure. Discussion of geometric nonlinearity, stress stiffening and buckling, bar, beam and plate elements, a general formulation, buckling load, stress stiffening and its uses.	
Course Outcomes (COs):	The students of the course should be able to – CO1: Classify various types of analysis for structural problems with engineering application and consequent use of finite element software. CO2: Explain vibration of thick plates, shells (as assembly of flat plates) and solid models using finite element method.	
	CO3: Compute buckling load and centrifugal stiffening effects as applied to rotating machines using various structural elements. CO4: Compute harmonic steady state response, transient response, non-harmonic response (using Fourier series) and random response (to forced excitation and base excitation problems) of structures. CO5: Understand material and geometric nonlinearity along with a few special topics in structural mechanics	

CO-PO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**1**	**1**	**1**											
CO2	**2**	**3**	**2**	**2**	**1**								**1**	**2**	
CO3	**2**	**3**	**2**	**2**	**2**								**1**	**2**	
CO4	**2**	**3**	**2**	**2**	**2**								**1**	**2**	
CO5	**3**	**2**	**1**	**1**											

Course Code: ME(M2)/PE/H/T/424B	Course Name: Reliability and Quality Engineering	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective IV	Nature of Course: Theoretical	
Course content/Syllabus:	Basic concept of reliability, Importance of reliability in design, Introduction to mathematical statistic and statistical distribution theorem. Basic reliability principles, Single probability, Load-strength interaction, Bath Tub curve, Non-constant failure rate, Introduction to simple Weibull plot. Introduction to reliability function, Structure functions, reliability of systems of independent components, bounds on the reliability function, the inclusion exclusion method, the intersection method. Replacement, maintenance and inspection: examples and policies, life time and failure rates, expected system life time, fixed time replacement, preventive replacement, group replacement, control limit rules. Introduction to quality control: examples and definitions, acceptance sampling, operating characteristic curve, sampling inspection plan, control charts, average run length, control chart construction, inspection problems, identification of risk factors, estimating survival functions. Reliability in design: defining the user requirement, setting reliability metrics and definitions, risk assessment, objective based framework for product development. Reliability in development, physics of failure, fault tree analysis, design reviews, critical items, production reliability, reliability qualification testing, failure mode effect analysis. Reliability assurance and maintainability, design from maintainability, logistic support analysis, life cycle costing, risk cost estimate, case studies.	

Course Outcomes (COs):	The students of the course should be able to – CO1: Explain the basic concepts of reliability, fundamental statistical distributions relevant to reliability and its importance in design CO2: Apply basic reliability principles to analyze and predict system reliability CO3: Analyze the reliability of systems with independent components using structure functions, reliability bounds, inclusion-exclusion methods and intersection methods CO4: Evaluate effective maintenance, replacement and inspection policies, including lifetime and failure rate analysis, preventive and group replacement strategies, and control limit rules CO5: Implement reliability principles in the design and development phases of design to ensure robust product development and lifecycle management.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**					**1**									
CO2	**3**	**2**				**2**								**2**	
CO3	**3**	**2**	**1**	**1**		**1**								**1**	
CO4	**3**	**2**				**1**	**1**							**1**	
CO5	**3**	**2**	**2**			**1**					**2**			**1**	

Course Code: ME(M2)/PE/H/T/424C	Course Name: Robotics	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective IV	Nature of Course: Theoretical	

Course content/Syllabus:	1. Robot definition, classification, anatomy, degrees of freedom, characteristics, role in automation and social issues. (2 pds) 2. Robot arm kinematics: transformation matrices, Denavit-Hartenberg representation in forward kinematics, inverse kinematics solution of robots. (6 pds) 3. Differential motions and velocities: Jacobian, differential motions of a frame, differential motions of a robot and its manipulator, inverse Jacobian; Development of dynamic equations for multi DOF manipulators using Lagrange mechanics. (10 pds) 4. Trajectory planning of robotic manipulator: Joint space vs. Cartesian space, Joint space trajectory planning (3rd, 5th and higher order polynomial trajectories), Cartesian space trajectories. (5 pds) 5. Actuators: actuating systems, hydraulic and pneumatic devices, electric motors (DC, AC, Brushless DC, Servo, Stepper). (3 pds)
	6. Sensors and Vision Systems: position sensors, velocity sensors, acceleration sensors, force and pressure sensors, torque sensors, light & infrared sensors, touch and tactile sensors, proximity sensors etc. Vision systems, image, image processing. (5 pds) 7. Robot Control: the control problem, Fuzzy control, Fuzzification, Defuzzification, Fuzzy logic in robotics. (8 pds) 8. Industrial applications of robots. (3 pds)
Course Outcomes (COs):	The students of the course should be able to – CO1: Explain the role of robotic automation in social context. CO2: Explain robot arm kinematics including forward and inverse kinematics. CO3: Analyze kinematics, differential motion and dynamics of multi DOF robotic manipulators. CO4: Analyze joint space and Cartesian space trajectories of robotic manipulators. CO5: Assess the use of actuators, sensors, vision system and control for robotic systems.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**					**2**									
CO2	**3**	**1**													
CO3	**3**	**2**	**2**			**1**								**1**	
CO4	**3**	**2**	**1**			**1**								**1**	
CO5	**2**	**2**												**1**	

Course Code: ME(M2)/PE/H/T/424D	Course Name: Introduction To Nonlinear Oscillations	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective IV	Nature of Course: Theoretical	

Course content/Syllabus:	Overview of linear vibration, Introduction to nonlinear oscillation, Examples of nonlinearities in vibration and commonly observed nonlinear phenomena; Sources and types of nonlinearity. (04) Development of nonlinear governing equation of motion of Mechanical systems. (03) Qualitative analysis: Introduction to phase plane, Trajectories and Separatrices, Concept of equilibrium and stability in nonlinear systems, Study of equilibrium points and stability. (05) Graphical Analysis: Method of Isoclines, Lienards method. (02) Quantitative analysis: Free vibration of conservative SDoF system with nonlinear restoring force, Exact method, Duffing equation, Perturbation techniques for weakly nonlinear systems. (12) Free vibration of non-conservative SDoF system, Negative damping and self-sustained systems, Van der Pol's oscillator and Van der Pol equation, Limit cycles. (06) Nonlinear forced vibration analysis, Jump phenomena, Multiple response, Superharmonic and Subharmonic response. (06) Parametrically excited systems, Mathieu equation, Hill equation, Strutt diagram, Stability Analysis, Lyapunov stability criteria. (04)
Course Outcomes (COs):	CO1. Describe fundamental knowledge (Sources, types, examples, differences with linear systems etc.) regarding nonlinear oscillations. (K2) CO2. Develop governing equations of motions of mechanical systems using fundamental concepts. (K3) CO3. Analyze stability of equilibrium points of nonlinear systems. (K4) CO4. Apply various solution methodologies (exact, approximate and graphical) to nonlinear free and forced vibration problems with and without damping. (K3) CO5. Explain nonlinear phenomena such as self-sustained oscillations, limit cycles, jump phenomenon, sub- and super-harmonic response etc. (K5)

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**1**										**1**			
CO2	**3**	**3**	**2**	**1**											
CO3	**3**	**1**	**1**												
CO4	**3**	**3**	**3**	**2**											
CO5	**3**	**1**	**1**	**2**											

Course Code: ME(M2)/PE/H/T/424E	Course Name: Advanced Thermodynamics	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective IV	Nature of Course: Theoretical	

Course content/Syllabus:	CLASSICAL THERMODYNAMICS Introduction. Definitions. 1hr The Zeroth law of thermodynamics and related topics. 2hrs The First law of thermodynamics for system and its corollaries. 1hr The Second law of thermodynamics for system and its corollaries. 3hrs Exergy for system. 2 System to control volume transition: Mass, Energy, Entropy and exergy balance equations. 2hrs Thermodynamic property relationships. Development of property tables and charts for pure substances. Residual properties. 3hrs Equations of state. Corresponding state correlations. 4hrs Partial properties. The ideal gas mixture. Fugacity and Fugacity coefficient. The ideal solution. Activity coefficient and excess properties. Real binary mixtures. Phase diagrams for binary systems. Vapour-Liquid

	equilibrium calculations. Chemical reaction stoichiometry, property changes of reaction. ChemicalReaction-Equilibrium calculations. 8hrs STATISTICAL THERMODYNAMICS Review of combinatory and probability theorems. 2hrs Molecular model. Collisions with a stationary wall. Pressure of a gas. Absolute temperature. Collisions with a moving wall. The Clausius equation of state. The van der Waals equation of state. 3hrs The distribution of molecular velocities. Evaluation of distribution constants. The error function. The energy distribution function. Molecular beams. Experimental verification of Maxwell velocity distribution. The principle of equipartition of energy. Classical theory of specific heats. Specific heats of a solid. 3 hrs Transport phenomena: Mean free path. Distribution of free paths. Coefficient of viscosity. Thermal conductivity. Coefficient of diffusion. Electrical conductivity. 3 hrs Maxwell-Boltzmann statistics: Phase space. Macrostates and microstates. Thermodynamic probability. Entropy and probability. The mono atomic ideal gas. The barometric equation. The principle of equipartition of energy. Theory of Para magnetism.3 hrs
Course Outcomes (COs):	The students of the course should be able to – CO1: Demonstrate understanding of the fundamental laws of thermodynamics CO2: Solve complex problems in classical thermodynamics by applying principles of thermodynamics CO3: Apply concepts of exergy, thermodynamic property relationships and equations of state to evaluate systems and control volumes CO4: Analyze phase diagrams, vapor-liquid equilibrium, and chemical reaction equilibria CO5: Assess statistical thermodynamics principles, including molecular velocity distributions, transport phenomena and Maxwell-Boltzmann statistics

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**														
CO2	**3**	**3**	**2**	**1**											
CO3	**3**	**2**					**2**							**2**	
CO4	**3**	**2**				**2**									
CO5	**3**	**3**		**1**										**1**	

Course Code: ME(M2)/PE/H/T/424F	Course Name: Advanced Power Generation	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective IV	Nature of Course: Theoretical	

Course content/Syllabus:	Demand and supply of electric power. Definition of different parameters and their significance. 03 Review of conventional power plants and their operation. Reheat and regeneration - significance and optimum solutions. 05 Limitations of conventional plants and future development trends. Identification of goals and constraints. 02 Combined power plant. Development, different schemes, thermodynamic analysis. Problem with high sulfur fuel. Supplementary firing -options and limitations. Performance evaluation. Retrofitting of existing plants. 08 Cogeneration -definition, advantages and limitations. Different schemes. Performance evaluation. 02 Environmental impact of power plants. Possible options. Different fluidized bed systems. 04 Gasification of coal. Advantages and constraints. Different options and development directions. Integrated gasification combined cycle (IGCC) power plants. Pre and post combustion carbon capture - advantages and limitations. Different schemes - thermodynamics. 06 Supercritical power plants. Thermodynamics, advantages and limitations. 02 Fuel cells. Large scale fuel cell integrated hybrid power and cogeneration plants. Schemes, advantages and limitations. 04 Membrane separation of gases and future trends of hybrid systems including renewable. 04
Course Outcomes (COs):	The students of the course should be able to – CO1: Review of conventional power plants and operation. CO2: Define the principle of combined power plant and performance evaluation. CO3: Define cogeneration and fluidized bed systems. CO4: Apply the concepts to integrated gasification combined cycle.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3

CO1	**3**	**1**													
CO2	**3**	**2**	**1**												
CO3	**2**	**3**	**1**												
CO4	**1**	**3**	**2**	**1**	**1**										

Course Code: ME(M2)/PE/H/T/424G	Course Name: Nuclear Power Engineering	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective IV	Nature of Course: Theoretical	

Course content/Syllabus:

Nuclear reaction, Nuclear Stability and Binding energy, Radioactive decay and half life, Nuclear Fission, Energy from fission, chain reaction, neutron energy, Thermal neutron, Nuclear cross section
(5 lectures)
Reactor theory, neutron diffusion equation, boundary condition, extrapolation distance, diffusion from point source, diffusion length, infinite plate source, slowing down, scattering, Average logarithmic energy decrement, moderating ratio, Criticality, Buckling. Reactors of various shapes. Multiplication factor, Neutron lifetime. Homogeneous and heterogeneous system, Critical mass, Thermal utilization factor.
Heavy water versus natural water moderator. Reflected reactor. (14 lectures)
Delay neutron, Positive and negative reactivity, Prompt-critical condition, Poisoning. (5 lectures)
Control of reactors, Control rods, Nuclear materials and fuels, coolants, moderator, shielding (6 lectures)
Thermal aspects and type of reactors: BWR, PWR, PHWR, FBR (12 lectures)

Course Outcomes (COs):

The students will be able to:
CO1: Interpret the working principles of Reactor Physics
CO2: Analyse different components of a nuclear reactor
CO3: Explain and differentiate various kind of nuclear power plants
CO4: Summarise the standard safety features of a nuclear power plant

CO-PO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**2**					**1**								
CO2	**3**	**3**	**2**				**1**								
CO3	**3**	**2**					**2**							**1**	**1**
CO4	**3**					**3**	**3**	**3**						**2**	**2**

Course Code: ME(M2)/PE/H/T/424H	Course Name: Introduction To Modern Control Theory	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective IV	Nature of Course: Theoretical	

Course content/Syllabus:

STATE SPACE ANALYSIS AND DESIGN - Introduction, state space models of SISO and MIMO mechanical systems – passive car suspension systems using quarter car and half car models, robotic manipulators; transfer function matrices and stability, solution of state equation – by Laplace Transform; formal solution: state transition; state variable feedback and pole placement. [10 HRS]
NONLINEAR CONTROL SYSTEMS - Common nonlinear behaviour of mechanical systems, concepts of phase plane analysis, singular points, constructing phase portraits, phase plane analysis of nonlinear systems, existence of limit cycles, concepts of stability, feedback linearization and the canonical form, input – state linearization, input – output linearization of SISO and MIMO systems; Lyapunov direct method, positive definite functions and Lyapunov functions, Lyapunov Stability Analysis: Stability of equilibrium state, asymptotic stability, graphical representation, Lyapunov's theorems, stability analysis of linear systems, nonlinear systems. [10 HRS]
SLIDING MODE CONTROL - Introduction, concept of variable structure control (VSC), ideal sliding motion and chattering, switching function, reachability condition, properties of sliding motion, design of first and second order sliding mode control (SMC) for an electrohydraulic actuation system. [8 HRS]
INTELLIGENT CONTROL - Artificial neural networks and its basic mathematical model, feed-forward multilayer perceptron, learning and training, neural control – direct and indirect; crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning, fuzzy knowledge and rule bases, fuzzification, inferencing and defuzzification – Mamdani's and TSK methods, fuzzy modelling and control, application of fuzzy and neural controllers for some active car suspension systems and electrohydraulic actuation systems. [12 HRS]

Course Outcomes (COs):	The students of the course should be able to – CO1: Construct state-space models SISO and MIMO mechanical systems. CO2: Analyse & solve state-space equations of MIMO mechanical systems. CO3: Identify different nonlinear behavior of mechanical systems; apply and analyze different techniques of nonlinear control systems CO4: Describe features of VSC and sliding mode control; design 1st and 2nd order SMC for electrohydraulic actuation systems. CO5: Describe features of neural networks and fuzzy logic control; design neural and fuzzy logic controllers for electrohydraulic actuation systems.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**														
CO2	**3**	**3**	**2**	**2**										**2**	
CO3	**3**	**3**	**2**			**2**								**2**	
CO4	**3**	**2**	**3**			**1**								**1**	
CO5	**3**	**2**	**3**			**1**								**1**	

Course Code: ME(M2)/PE/H/T/424I	Course Name: Maintenance And Safety Engineering	
Credits: 4	Contact Hours/Week (L-T-P): 4-0-0	Full Marks: 100
Category of Course: Honours Professional Elective IV	Nature of Course: Theoretical	

Course content/Syllabus:	**Part I: Maintenance Engineering**
	Introduction, Background, Objectives, Maintenance in 21st Century, Maintenance Mathematics, Maintenance Management and Control, Preventive Maintenance, Corrective Maintenance, Reliability Centered Maintenance, Inventory control in Maintenance, Human error in maintenance, Quality and Safety in maintenance, Maintenance costing, Software maintenance, Maintainability analysis **Part II: Safety Engineering** Inherent safety design, Risk Assessment, HAZOP Techniques, Human factors, Maintenance for safety improvement, Mechanical Safety, Environmental safety
Course Outcomes (COs):	The students of the course should be able to – CO1: Discuss effective maintenance functions CO2: Describe the strategy to preserve equipment function and avoid its failure CO3: Discusses various aspects related to maintenance management and control, including department functions and organizations CO4: Illustrates basic principles of Safety management

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**	**1**				**1**					**2**				
CO2	**3**	**1**				**2**								**1**	**2**
CO3	**3**	**2**				**1**					**2**	**1**			
CO4	**2**	**1**				**2**					**1**	**2**			