DEPARTMENT OF MECHANICAL ENGINEERING

PSO

Program Specific Outcomes (PSOs) of the B. Tech. in Mechanical Engineering are as follows:

1. Able to design, analyse and interpret data to solve industrial problems applying Mechanical Engineering and interdisciplinary knowledge.
2. Able to use engineering tools and techniques to solve the real life problems of Mechanical Engineering.
3. Able to communicate effectively and succeed in competitive examinations.
4. Able to develop confidence for self-education and lifelong learning.

COURSE STRUCTURE

Semester I/II

S. N.	Code	Subject	L	T	P	Credits
1.	ME 101	Engineering Mechanics	3	1	0	4
2	ME 111	Workshop Practice	0	0	3	2
		Total contact hours/credits	3	1	3	6

Semester III

S. N.	Code	Subject	L	T	P	Credits
1.	ME 201	Basic Thermodynamics	3	1	0	4
2	ME 202	Theory of Machines	3	1	0	4
3	MA 103	Mathematics III	3	1	0	4
4	ME 203	Fluid Mechanics – I	3	1	0	4
5	ME 204	Manufacturing Process	3	0	0	3
6	ME 205	Material Science	3	0	0	3
7	ME 211	Machine Drawing Lab	0	0	3	2
8	ME-212	Manufacturing Lab	0	0	3	2
9	ME 213	Thermo-Fluid Lab-I	0	0	3	2
		Total contact hours/credits	18	4	9	28

Semester IV

S. N.	Code	Subject	L	T	P	Credits
1.	ME 206	Applied Thermodynamics	3	1	0	4
2	ME 207	Fluid Mechanics – II	3	1	0	4
3	ME 208	Mechanics of Solids	3	1	0	4
4	ME 209	Instrumentation and Measurement	3	0	0	3
5	ME 210	Machining and Machine Tools	3	0	0	3
6	ME 217	Energy Science and Technology	3	0	0	3
7	ME 214	Material Testing Lab	0	0	3	2
8	ME 215	Instrumentation and Measurement Lab	0	0	3	2
9	ME 216	Thermo-Fluid Lab - II	0	0	3	2
		Total contact hours/credits	18	3	9	27

Semester V

S. N.	Code	Subject	L	T	P	Credits
1.	ME 301	Heat Transfer	3	1	0	4
2	ME 302	Machine Design - I	3	1	0	4
3	ME 303	Turbomachinery	3	1	0	4
4	ME 304	Advanced Solid Mechanics	3	1	0	4
5	ME 305	I. C. Engine	3	0	0	3
6	ME 306	Advanced Manufacturing Process	3	0	0	3
7	ME 311	Fluid Machinery Lab	0	0	3	2
8	ME 312	Machining Lab	0	0	3	2
9	ME 313	Heat Transfer Lab	0	0	3	2
		Total contact hours/credits	18	4	9	28

Semester VI

S. N.	Code	Subject	L	T	P	Credits
1.	ME 307	Machine Design – II	3	1	0	4
2	ME 308	Automobile Engineering	3	1	0	4
3	ME 309	Power Plant Engineering	3	1	0	4
4	ME 310	Dynamics and Control of Machinery	3	1	0	4
5	ME 3XX	Deptt. Elective - I	3	0	0	3
6	ME 3XX	Open Elective I	3	0	0	3
7	ME 314	Automobile Lab	0	0	3	2
8	ME 315	Dynamics Lab	0	0	3	2
9	ME 316	Machine Design Lab	0	0	3	2
		Total contact hours/credits	18	4	9	28

Semester VII

S. N.	Code	Subject	L	T	P	Credits
1	ME 401	Industrial Engineering and Operations Research	3	0	0	3
2	ME 4XX	Deptt. Elective - II	3	1	0	4
3	ME 4XX	Open Elective II	3	0	0	3
4	HS 401	Managerial Economics	3	0	0	3
5	ME 497	Industrial Training (Minimum 6 weeks)				2

5	ME 498	Project I	0	0	6	4
		Total contact hours/credits	12	1	6	19

Semester VIII

S. N.	Code	Subject	L	T	P	Credits
1	HS 401	Business Managment	3	0	0	3
2	ME 4XX	Deptt. Elective - III	3	0	0	3
3	ME 4XX	Open Elective III	3	0	0	3
4	ME 499	Project II	0	0	6	6
		Total contact hours/credits	9	0	6	15

Department Elective I (6th Semester)

S. N.	Code	Subject
1.	ME 331	Computer Numerical Control of Machine Tools
2.	ME 332	Diagnostic Maintenance of Mechanical Equipments
3	ME 333	Plant Layout and Automated Material Handling
4	ME 334	Ferrous and Nonferrous Material
5	ME 335	Fuel and Combustion
6	ME 336	Theory of Elasticity and Plasticity
7	ME 337	Gas Dynamics
8	ME 338	Gas Turbine and Jet Propulsion
9	ME 339	Metal Cutting and Cutting Tool Design

Department Elective II (7th Semester)

S. N.	Code	Subject
1.	ME 431	Advanced Machining Process
2.	ME 432	Convective Heat and Mass Transfer
3	ME 433	Fundamentals of Industrial Design
4	ME 434	Viscous Fluid Flow
5	ME 435	Mechanics of Composite Materials
6	ME 436	Computer Aided Design
7	ME 437	Refrigeration

Department Elective III (8th Semester)

S. N.	Code	Subject
1.	ME 451	Computer Integrated Manufacturing
2	ME 452	Condition Monitoring of Manufacturing Processes
3	ME 453	Engineering Fracture Mechanics
4	ME 454	Heat Transfer Application in Biological Systems
5	ME 455	Mechanical Vibration
6	ME 456	Two Phase Flow
7	ME 457	Air Conditioning

Open Elective I (6th Semester)

S. N.	Code	Subject
1.	ME 381	Computational Fluid Dynamics
2.	ME 382	Finite Element Method
3	ME 383	Reliability Engineering
4	ME 384	Renewable Energy
5	ME 385	Engineering Inspection and Quality Control

Open Elective II (7th Semester)

S. N.	Code	Subject
1.	ME 481	Battery and Fuel Cell Technologies
2.	ME 482	Mechatronics
3	ME 483	Uncertainty Quantification
4	ME 484	Hydraulic Machines

Open Elective III (8th Semester)

S. N.	Code	Subject
1.	ME 491	Interfacial Instability and Applications
2	ME 492	MEMS and Nanotechnology
3	ME 493	Microscale Transport Processes
4	ME 494	Pollution Control and Management
5	ME 495	Solar Architecture

Syllabi

ME 101 Engineering Mechanics L T P C

B. Tech (Mechanical Engg.) First/Second Semester (Core) 3 1 0 4

Unit-1 STATICS

Statics of rigid bodies: Classification of force systems- principle of transmissibility of a force Composition and resolution- Resultant of a coplanar force systems and conditions of equilibrium, free body diagrams.

Moment of a force, couple, properties of couple- Varignon's theorem, Concurrent and parallel forces, conditions of equilibrium.

Beams: Types of loading, Support reactions of simply supported and overhanging beams under different types of loading.

Friction: Laws of dry friction - Angle of friction - Cone of friction - Ladder friction, Wedge friction, Belt friction, Simple Screw Jack.

Properties of surfaces: Centroid of simple and composite areas- Theorems of Pappus and Guldinus.

Moment of inertia of areas, Parallel and perpendicular axes theorems- Radius of Gyration, moment of inertia of simple and composite areas.

Plane Truss: Statically determinate trusses; Analysis of a truss and frames - Method of joints, Method of section, Method of Members.

Virtual Work: Degree of freedom, Virtual displacement and virtual work; Principle of virtual work.

Unit-2 DYNAMICS

Kinematics of Particles: Differential equations of kinematics; Cartesian coordinate system; Normal and tangent co-ordinate system, projectile motion.

Kinetics of Particles: Kinetics of rectilinear and curvilinear motion, D'Alemberts Principle, Principle of impulse and momentum, Work, energy and power, Direct and oblique collision.

Rotation of Rigid Bodies: Moment of inertia of material bodies, Kinematics and Kinetics of rotation equation of motion, Principle of work and energy;

Principle of impulse and momentum.

Plane motion of Rigid Bodies: Translation of a rigid body in a plane; Kinematics of plane motion; Instantaneous center of rotation; Kinetics of plane motion – equation of motion, principle of work and energy; Principle of impulse and momentum.

Text Books:

1. S. Timoshenko, D. H. Young, J.V. Rao, S. Pati. ***Engineering Mechanics,*** McGraw Hill Education; 5/e.
2. J. L. Meriam & L.G. Kraige. ***Engineering Mechanics -Statics,*** John Wiley & Sons, Inc; 3/e.
3. J. L. Meriam & L.G. Kraige. ***Engineering Mechanics -Dynamics,*** John Wiley & Sons, Inc; 3/e.
4. F. P. Beer, Jr., E. R. Johnston, E. R. Eisenberg, P. J. Cornwell, D. Mazurek. ***Vector Mechanics for Engineers- Statics & Dynamics,*** McGraw-Hill Higher Education; 9/e.

Reference Books:

1. R.C. Hibbeler. ***Engineering Mechanics - Statics & Dynamics,*** Pearson Education, 4/e.
2. Rogers and M A. Nelson. ***Engineering Mechanics Statics and Dynamics,*** McGraw Hill Education; 1/e.
3. K. L. Kumar, V. Kumar. ***Engineering Mechanics,*** McGraw Hill Education; 4/e.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. identify and analyze the problems by applying the fundamental principles of engineering mechanics and proceed to design and development of the mechanical systems.

ME 111 Workshop Practice L T P C

B. Tech (Mechanical Engg.) First/Second Semester (Core) 0 0 3 2

Unit-1 General safety precautions in workshop and introduction.

Unit-2 Carpentry Shop: Safety precaution, Kinds of wood and timber, Application of timber as per their classification, Carpentry hand tools and machines, Different types of carpentry joint, Demonstration of wood working

machine like, band saw, circular saw, thickness planner, wood working lathe, surface planners, etc.

Unit-3 Welding Shop: Safety precaution in welding shop, Introduction to gas and arc welding, Soldering and brazing etc. Welding equipment and welding material.

Unit-4 Fitting Shop: Safety precaution, Introduction to fitting shop tools, equipment, Operation and their uses, Marking and measuring practice.

Unit-5 Machine Shop: Safety precautions, Demonstration and working principles of some of the general machines, like lathe, shaper, milling, drilling , grinding, slotting etc., General idea of cutting tools of the machines.

Text Books:

1. S K Hajra Choudhury, A K Hajra Choudhury, N. Roy. ***Workshop Technology Vol I & II,*** Media Promoters & Publishers Pvt. Ltd; 9/e.

Reference Books:

1. H S Bawa. ***Workshop Practice,*** McGraw Hill Education; 2nd edition, 2/e.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. know the importance of general safety precautions on different shop floors.
2. identify the basics of tools and equipments used in fitting, carpentry, sheet metal, machine, welding and smithy.
3. do fabrication of wooden joints and understand joining of metals.
4. make metal joints and sheet metal work.
5. understand the basics of removal of material from work piece surface to attain specific shape.
6. familiarize with the production of simple models in fitting, carpentry, sheet metal, machine, welding and smithy trades.

ME 201	Basic Thermodynamics	L T P C
	B. Tech (Mechanical Engg.) Third Semester (Core)	3 1 0 4

Unit-1 Concepts of Thermodynamics: Macroscopic and Microscopic concepts, System and its classification. Thermodynamic state, properties, process and cycles, Thermodynamic equilibrium, Energy interactions (Work transfer and its different modes, Heat transfer).

Unit-2 First Law of Thermodynamics: First law applied to non-flow as well as flow processes, Concepts of internal energy, Enthalpy, Specific heats, PMMI, Energy equations for flow systems, Application of energy equations to different engineering components.

Unit-3 Second Law of Thermodynamics: Need of the Second Law, Preliminary definitions, Different statements of the Second law of Thermodynamics and their equivalence, Reversibility and irreversibility, Causes of irreversibility, Reversible cycles, Carnot theorem, Absolute thermodynamic temperature scale, Third law of Thermodynamics.

Unit-4 Entropy: Clausius theorem and inequality, Entropy principle, Entropy and disorder, Evaluation of entropy change during various processes, T-s and H-s diagrams, and Concept of Third law of Thermodynamics.

Unit-5 Properties of Substances: Gases-Equation of state of an ideal gas, Specific heats, Internal energy, Enthalpy and Entropy change of ideal gas, Equation of state of Real Gases, Principle of corresponding state, Compressibility Factor.

Unit-6 Steam – Definition of sensible heat, Latent heat, Saturation temperature, Quality, Evaluation of properties from Steam table and Mollier diagram. Concept of Exergy Analysis: Concept of exergy, Irreversibility, exergy balance, exergy transfer accompanying heat, exergy transfer accompanying work, flow exergy, exergy balance for control volume. Exergetic efficiency, exergetic efficiencies of common components: turbines, pumps, nozzles etc.

Text Books:

1. Cengel and Boles. ***Thermodynamics: An Engineering Approach, 7/e***. Tata McGraw Hill.
2. Moran, Shappiro, Boettner and Bailey. ***Principles of Engineering Thermodynamics, 8e***. Wiley.

3. P.K. Nag. ***Engineering Thermodynamics, 5/e***. McGraw Hill.

Reference Books:

1. Boegnakke and Sonntag. ***Fundamentals of Thermodynamics: 7e***. Wiley.
2. Rogers and Mayhew. ***Engineering Thermodynamics, 4e***. Pearson Education.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. develop the basic concepts of thermodynamic systems, equilibrium and fundamental laws of engineering thermodynamics.
2. apply first law of thermodynamics to various closed and open systems.
3. apply second law of thermodynamics to closed and open systems to calculate specified parameters such as work, heat transfer, or entropy.
4. apply the basic principles of classical thermodynamics to the analysis of processes and cycles involving pure simple substances.
5. calculate exergy destruction for various processes carried out on various thermal devices.
6. identify and formulate elementary level engineering problems related to thermodynamics and energy transformation in a conceptual form as well as in terms of mathematical/physical models.

ME 202 Theory of Machines L T P C

B. Tech (Mechanical Engg.) Third Semester (Core) 3 1 0 4

Unit-1 Introduction and Kinematic Analysis of Mechanisms: Introduction, kinematics and dynamics of machines, machine, mechanism, and structure, mobility of mechanisms, kinematic inversion, Grashof's law, synthesis of mechanism, straight line generating mechanisms, intermittent motion mechanism, transmission angle-determination of minimum value, position analysis analytic and graphical approach, kinematic analysis of the slider-crank mechanism and four-bar mechanism, solutions of loop-closure equations.

Unit-2 Velocity and Acceleration Analysis of Mechanisms: Velocity analysis analytic and graphical approach, equations for velocities, applications to simple and compound mechanisms, acceleration analysis, Analytical and

Graphical approach, equations for accelerations, applications to simple mechanisms, free-body diagram for a link, application to simple and compound mechanisms.

Unit-3 Cam and Follower: Classification of followers and cams, motion of the follower, displacement, velocity and acceleration diagrams, construction of cam profiles. Governors: Types and application, Functions of a Governor, Characteristic of centrifugal governors, Quality of Governor: Definitions of controlling forces, stability, sensitiveness, isochronisms, capacity and coefficient of insensitiveness, Spring controlled governors of Hartnell and Hartung types, Effect of friction, Effort and power, Effect of Friction: Insensitiveness.

Unit-4 Balancing: Static and dynamic force diagram, Inertia forces and their balancing for rotating and reciprocating machines, Identification of inertia forces for reciprocating masses in engine mechanisms, Partial primary balance of single cylinder engines and uncontrolled locomotives, Balancing of multi cylinder in line engines, V- twin engines, Radial engines – direct and reverse crank methods.

Unit-5 Gears: Friction wheels, gear drives and classifications, gear terminology, law of gearing, velocity of sliding of teeth, forms of teeth: cycloidal and involute, centre distance, length of path of contact, length of arc of contact, contact ratio, interference in involute gears, minimum number of teeth on the pinion, minimum number of teeth on the wheel, minimum number of teeth on a pinion for involute rack in order to avoid interference, spur gears, helical gears, spiral gears.

Unit-6 Gear Trains: Introduction, types of gear trains, simple gear train, compound gear train, design of spur gears, reverted gear train, epicyclic gear train, velocity ratio of epicyclic gear train, compound epicyclic gear train (sun and planet wheel), epicyclic gear train with bevel gears, torques in epicyclic gear trains, analytical and tabular method for solving the problems on gear trains.

Text Books:

1. S. S. Rattan. ***Theory of Machines***. Tata McGraw Hill Publication.
2. Oleg G. ***Fundamentals of Kinematics and Dynamic of Machines and Mechanisms***. CRC Press.

3. John J. Uicker, Gordon R. Pennock, Joseph E. Shigley. T***heory of Machines and Mechanisms***. Oxford University Press.

Reference Books:

1. Norton. ***Design of Machinery***. McGraw Hill Publishers.
2. David H. Myszka. ***Machines and Mechanisms***. Pearson Education, Inc., publishing as Prentice Hall, One Lake Street, Upper Saddle River, New Jersey.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. learn and comprehend the basics of mechanisms, joints, components and degrees of freedom.
2. Understand the fundamentals of theories and engineering applications of dynamics of machines.
3. design and analyze the basics of synthesis and simple mechanisms.
4. design and analyze the cam-follower, gears and gear train.
5. analyze the operation of governor and balancing of masses

ME 203 Fluid Mechanics – I L T P C

B. Tech (Mechanical Engg.) Third Semester (Core) 3 1 0 4

Unit-1 Introduction: Definition of fluid, continuum hypothesis, different properties of fluid, classification (like Newtonian/non-Newtonian, ideal/real etc.).

Unit-2 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.

Unit-3 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.

Unit-4 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. Application of Linear and Angular Momentum equation: linear momentum equation; analysis of force exerted by a fluid stream on a solid boundary – jet impingement, thrust on pipe bends etc. Principle of Conservation of Angular Momentum and its application. Steady Flow Energy Equation and its application.

Unit-5 Characteristics of Laminar and Turbulent Flow: Reynolds experiment, critical Reynolds number; laminar flow through pipe – Hagen Poiseuille equation.

Unit-6 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.

Free Surface Flow: Flow in open channel, Chezy's equation, Manning's equation, economical cross section, specific energy, hydraulic jump.

Text Books:

1. S.K. Som, G. Biswas and S. Chakraborty. ***Introduction to Fluid Mechanics and Fluid***. Tata McGraw Hill.
2. Cengel and Cimbala, ***Fluid Mechanics***. Tata McGraw Hill.

Reference Books:

1. R.W. Fox, P.J. Pritchard and A. T. McDonald. ***Introduction to Fluid Mechanics***. Wiley.
2. Frank M. White. ***Fluid Mechanics***. McGraw Hill.

3. A. K. Jain. ***Fluid Mechanics***. Khanna Publishers.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. describe the basic concepts of fluid mechanics and recognize the various types of fluid flow problems encountered in practice.
2. determine the variation of pressure in a fluid at rest and also calculate the forces exerted by a fluid at rest on plane or curved submerged surfaces.
3. apply the role of material derivative in transforming between Lagrangian and Eulerian descriptions, and explain the four fundamental kinematic properties of fluid motion and deformation.
4. derive and apply various conservative equations related to fluid flow problems.
5. develop fundamental understanding about the techniques of numerical solution of fluid flow problems.

ME 204 Manufacturing Process L T P C

B. Tech (Mechanical Engg.) Third Semester (Core) 3 0 0 3

Unit-1 Introduction to manufacturing process: Classification: casting, forming, fabrication and material removal processes.

Unit-2 Metal casting process: Introduction: History, advantages and limitation, application, casting terms, sand mould making; Patter: Pattern allowances, Pattern material; Moulding materials: Moulding sand composition, Moulding sand properties, Testing of sand properties, sand preparation, moulding machines, Moulding process; Cores: core material, core prints, core moulding process and chaplets; Forces acting on the Moulding flasks; Gating system for casting: Introduction, Gating system design and pouring time calculation; Riser Design: methods, chills; Introduction to melting practices: furnaces, inoculation, degasing, ladles; sand casting; Casting defects: Gas defects, Mould material defects, pouring metal defects, metallurgical defects; Introduction to nondestructive testing. Special Casting processes: Pressure die casting, centrifugal casting, and continuous casting, Blow moulding, Injection moulding.

Unit-3 Metal forming Processes: Concept of plastic deformation: hot working,

cold working; Various metal forming techniques and their analysis: forging: types, analysis, forging defects; Rolling: Principle, rolling load, rolling defects; Extrusion: principles, classification, hot extrusion, cold extrusion, load estimation for extrusion, extruding tubes; Wire drawing, Rod and Tube drawing.

Unit-4 Sheet Metal operation: Basic principle, press tool operation, shearing operation: Parting, notching, blanking and piercing; Drawing: Cupping (drawing), Deep drawing. Design of blanks for any shearing and cupping operation. Bending: load estimation for bending; spinning, stretch forming, coining and embossing; Sheet metal die design: Types of dies, Die and punch design.

Unit-5 Welding process: Introduction: fabrication methods, classification: Classification based on application of filler material & without filler material, source of energy, fusion and pressure welding processes, Gas welding: Types of flames, Gas cutting. Electric Arc welding: principle of arc, arc welding equipment, AC and DC welding equipment, DC straight polarity (DCEN) and DC reverse polarity (DCEP) welding; Electrodes; Manual metal arc welding; arc blow; Tungsten Inert Gas (TIG) welding, Metal Inert Gas (MIG) welding, Gas Metal Arc Welding (GMAW), Submersed Arc Welding (SAW); Resistance welding: Principle, Resistance spot welding, Resistance seam welding, projection welding, upset welding.

Unit-6 Welding Design: Heat input, Heat flow and welding defects. Other fabrication process like Electro-Slag welding, Forge welding, Brazing, Braze welding, soldering, adhesive bonding etc. A brief introduction to Powder metallurgy and its application..

Text Books:

1. P N Rao. ***Manufacturing Technology: Foundry, Forming and Welding***. Tata McGraw Hill.
2. A Ghosh and A K Mallik. ***Manufacturing Science.*** Pearson.
3. S Kalpakjian and S R Schmid. ***Manufacturing Processes for Engineering Materials***. Pearson education.

Reference Books:

1. Richard Heine, Carl Loper, Philip Rosenthal**.** ***Principles of Metal Casting***. McGraw Hill Education.
2. B.S. Nagendra Parashar and R.K. Mittal. ***Elements of Manufacturing Processes***. PHI.
3. S K Hajra Choudhury, S K Bose, A K Hajra Choudhury. Nirjhar Roy. ***Workshop Technology Vol I***. Media Promoters & Publishers Pvt. Ltd.
4. J. T. Black and Ronald A. Kohser. ***Materials and Processes in Manufacturing***. Wiley.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. identify and apply different manufacturing process for various product.
2. select appropriate moulding material for making a sound mould.
3. design pattern, cores, and mould for the metal casting process.
4. identify the casting defect with cause.
5. select appropriate metal forming processes for manufacturing of product.
6. calculate load requirement for metal forming process (forging, rolling, and extrusion).
7. select appropriate sheet metal operation for manufacturing product.
8. analyse different operations like shearing, drawing and bending.
9. select appropriate welding process as per engineering application.
10. select welding parameters for sound welding.
11. apply the knowledge for producing defect free welding.
12. select suitable manufacturing process for powder metallurgy components.

ME 205 Material Science L T P C

B. Tech (Mechanical Engg.) Third Semester (Core) 3 0 0 3

Unit-1 Introduction to Materials Science and engineering: Historical perspective and materials science, why study materials science and engineering? Classification of materials, functional classification of materials, environmental and other effects on materials, materials design and selection. Atomic structure: Atomic structure and atomic bonding in solids, crystal structures, crystalline and non-crystalline materials, miller indices.

Unit-2 Imperfections in solids: Theoretical yield strength, point defects, line defects and dislocations, interfacial defects, bulk or volume defects and atomic vibrations. Kinetics of phase transformation, crystallization, nucleation, homogenous nucleation, heterogenous nucleation, crystal

growth, dendritic growth. Dislocations and Strengthening Mechanisms: Dislocations & plastic deformation and mechanisms of plastic deformation in metals, strengthening mechanisms in metals, recovery, recrystallization and grain growth.

Unit-3 Phase transformations and phase equilibrium: Useful terminology, equilibrium phase diagrams, particle strengthening by precipitation and precipitation reactions, kinetics of nucleation and growth, the iron–carbon system, phase transformations, Normalising, Annealing, Spheroidising, transformation rate effects and TTT diagrams, Continuous cooling curve, microstructure and property changes in Fe-C alloys.

Unit-4 Mechanical properties of Metals: Interpretation of tensile stress-strain curves, normal stress strain curve, true stress strain curve, toughness and resilience, elastic deformation and plastic deformation, yielding under multi-axial stress, yield criteria, macroscopic aspects of plastic deformation and property variability & design considerations.

Unit-5 Failure: Fracture, Ductile and brittle fracture, fracture mechanics, impact fracture testing, ductile-to-brittle transition, fatigue, crack initiation and propagation, crack propagation rate, creep, generalized creep behavior, stress and temperature effects.

Unit-6 Applications and Processing of Polymers: Polymer types and Polymer synthesis & processing, crystallization, melting and glass transition, mechanical behavior of polymers, mechanisms of deformation and strengthening of polymers, characteristics and typical applications of few plastic materials, particle-reinforced composites, fiber-reinforced composites, structural composites.

Unit 7 Economic, Environmental and social issues of material usage: economic considerations, environmental and social considerations, recycling issues, life cycle analysis (LCA) and its use in design.

Text Books:

1. Avner. ***Introduction to Physical Metallurgy***. Mc Graw hill.
2. Smith***. Material Science & Engineering, 4/e***. McGraw-hill.
3. Dieter. ***Mechanical Metallurgy, 3/e***. McGraw-Hill.

Reference Books:

1. Callister***. Material Science and Engineering***. John Wiley & Sons. Inc.
2. Askeland & Fulay. ***The Science and Engineering of Materials***. Nelson Engineering,

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. apply core concepts in materials science to solve engineering problems.
2. understand the professional and ethical responsibilities of a materials scientist and materials engineer.
3. describe its physical origin, as well as strength for a particular bond associated with the atomic structure.
4. determine the theoretical yield strength for a given metal or alloy based on imperfections.
5. solve simple diffusion problems.
6. differentiate various metal treatment processes.
7. identify the mechanical properties and failure modes of materials.
8. describe a polymer's elastic behavior above and below the glass transition.
9. describe properties of structural composites.
10. solve problems related to materials.
11. identify structure property correlation for material design for different applications.

ME-211	Machine Drawing Lab	L	T	P	C
	B. Tech (Mechanical Engg.) Third Semester (Core)	**0**	**0**	**3**	**2**

Unit-1 ISI conventions in drawing Surface finish, Limits, Fits and tolerance (to be indicated on working drawings), Orthographic projection of different types of composite bodies.

Unit-2 Bolts and nuts, Keys, Pins, Setscrews, Riveted joints, Welded joints, Pipe joints, Flanged coupling, Flat and V-belt pulleys, Threads (internal and external), Studs, Washers, Springs, Plain journal bearing, Ball and roller bearings.

Unit-3 Assembly and part drawings for parts such as: Stuffing box, Foot step bearing, Plummer block, Universal joints, Gear pump, Screw jack, Cross head of steam engine, Connecting rod, Piston assembly, Stuffing box, Eccentric sheave, Tail stock.

Text Books:

1. N. D. Bhatt. ***Machine Drawing***: Charotor Publishing House, Anand
2. Ajeet Singh. ***Machine Drawing***, 2/e: Tata Mc Graw Hill Publishing
3. K.L. Narayana, P. Kannaiah & K. Venkata Reddy. ***Production Drawing***: New Age International Publisher

Reference Books:

1. R.K. Dhawan. ***A Text Book of Machine Drawing***: S. Chand & Company Publishing House
2. B. Bhattacharyya. ***Machine Drawing***, Oxford Higher Education
3. K. C. John. ***Text Book of Machine Drawing***, Prentice Hall India (PHI)

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. have basic thoughts and ideas on practical working drawing of machinery components
2. gain knowledge on assembly drawing of machine parts.
3. understand how to prepare bill of materials (part-list) in working drawing.
4. understand and comprehend the sectional view of assembly of machine components.
5. understand the type of fit and tolerances used in assembly of components.

ME-212 Manufacturing Lab L T P C

B. Tech (Mechanical Engg.) Third Semester (Core) 0 0 3 2

Unit-1 Practice of different welding processes - SAW, TIG, MIG, resistance welding, friction welding etc.; introduction to soldering, brazing etc.; making welded joints using different welding processes.

Unit-2 Introduction to forging tools, furnaces and forging machines; to practice basic forging operations drawing out, upsetting, necking etc.; introduction to forge welding. Surface preparation and etching techniques, heat treatment and metallographic studies.

Unit-3 Introduction to moulding practice - preparation of moulding sand (green & dry) and use of moulder's tools; making of moulds by using selected pattern's; gating system design, melting and pouring practice; sand preparation, sand testing: specimen preparation, permeability, clay content, grain fineness number, green compression strength, green shear strength, dry strength, hardness etc.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. design patterns, gating, runner and riser systems.
2. design and develop a product using various metal casting methods.

3. perform various arc and solid state welding processes and select a suitable process based on the application and requirements.
4. fabricate machine components with suitable welding technique.
5. choose a suitable mechanical press working process to obtain the required shape of metal.
6. perform the various types of dies like blanking & piercing operations and study of simple, compound and progressive dies.
7. study the structural characteristics or constitution of a metal or an alloy in relation to its physical and mechanical properties.

ME 213	**Thermo-Fluid Lab-I**	**L T P C**
	B. Tech (Mechanical Engg.) Third Semester (Core)	**0 0 3 2**

Unit-1 Verification of the Bernoulli's theorem, Verification of the law of equilibrium of a floating body, Determination of the coefficient of discharge using flow measuring devices, Determination of the drag and lift forces on an aerodynamic body.

Unit-2 Determination of coefficient of discharge using notches and weirs, Determination of major and minor losses in flow conduits, Determination of velocity of air using pitot tube, Calibration of a thermocouple.

Unit-3 Determination of dryness fraction of steam using throttling calorimeter, Determination of viscosity of oil.

Course Outcomes (COs):
Upon the completion of this course, the students are expected to:

1. correlate and verify Bernoulli's theorem.
2. use flow measuring devices to measure the coefficient of discharge.
3. correlate the phenomenon of equilibrium of any floating body and hence calculate metacentric height of a floating body.
4. visualize flow in an open channel with varying flow discharges and be able to calculate the coefficient of discharge.
5. draw the performance plots and analyse performance of the devices from the plots.
6. calculate the major and minor losses in flow using pitot tube.
7. calibrate a thermocouple.
8. calculate dryness fraction of steam.

ME 206	Applied Thermodynamics	L T P C
	B. Tech (Mechanical Engg.) Fourth Semester (Core)	3 1 0 4

Unit-1 Thermodynamic property relations: Maxwell relation, specific heat relations, relations for changes in internal energy, enthalpy and entropy, Clapeyron equation, Joule-Thomson coefficient, generalized relations and charts for residual enthalpy and entropy.

Unit-2 Gas Power Cycle: An overview of reciprocating IC engines, working principle of 2-stroke and 4-stroke engines, Air-standard cycles for IC engines. An overview of gas turbine, its classification, air-standard cycle for gas turbine.

Unit-3 Vapour and combined power cycle: Carnot cycle, Rankine cycle, actual vapour power cycle processes, reheat cycle, regenerative cycle, feed water heaters (open and closed), characteristics of an ideal working fluid in vapour power cycle, binary vapour cycles, thermodynamics of combined cycles.

Unit-4 Reciprocating air compressor: Single stage and multistage air compressors, work done per cycle, compressor capacity and power calculation, volumetric efficiency and isothermal efficiency, effect of clearance ratio on volumetric efficiency, intercooler and after cooler.

Unit-5 Refrigeration and Psychrometry: Gas cycle refrigeration, vapour compression refrigeration, vapour absorption refrigeration, types of refrigerants and properties of ideal refrigerants, psychrometric properties and processes, psychrometric chart.

Unit-6 Combustion processes: Fuels and combustion, theoretical and actual combustion processes, enthalpy of formation and enthalpy of combustion, first law analysis of reacting systems, adiabatic flame temperature, entropy change of reacting systems, second law analysis of reacting systems.

Text Books:

1. Cengel and Boles. ***Thermodynamics: An Engineering Approach, 7/e***. Tata McGraw Hill.
2. Moran, Shappiro, Boettner and Bailey. ***Principles of Engineering Thermodynamics,*** *8/e*. Wiley.

Reference Books:

1. P.K. Nag. ***Engineering Thermodynamics, 5/e***. McGraw Hill
2. Boegnakke and Sonntag. ***Fundamentals of Thermodynamics: 7e***. Wiley.
3. Rogers and Mayhew. ***Engineering Thermodynamics, 4e***. Pearson Education.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. describe vapor power cycles, gas power cycles and be able to design basic components of power plant.
2. perform analysis of various refrigeration and heat pump cycles using various working fluids.
3. apply the concept of Psychometry for the analysis of heating, drying and air conditioning systems.
4. demonstrate the ability to apply the first and second laws to combustion processes.
5. describe and design of a reciprocating air compressor.
6. develop fundamental relations between commonly encountered thermodynamic properties and express the properties that cannot be measured directly in terms of easily measurable properties.

ME 207 Fluid Mechanics -II L T P C

B. Tech (Mechanical Engg.) Fourth Semester (Core) 3 1 0 4

Unit-1 Basic concept of turbulence and turbulent flow. Equation of motion for viscous flow: Two-dimensional laminar flow between flat parallel plates and annulus.

Unit-2 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.

Unit-3 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.

Unit-4 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.

Unit-5 Dimensional analysis: Dimensional analysis and Buckingham Pi theorem; similarity and model studies. Unsteady flow – water hammer

Unit-6 Principles of Fluid Machines: Introduction, classification of fluid machines, hydraulic turbines and pumps. Numerical solution of fluid mechanics problems: Numerical solution of fluid mechanics problems and its applications in Computational Fluid Dynamics.

Text Books:

1. Som, Biswas and Chakraborty. ***Introduction to Fluid Mechanics and Machines***. Tata McGraw Hill Publ.
2. J. D. Anderson. ***Modern Compressible Flow***. McGraw Hill.

3. Cengel and Cimbala. ***Fluid Mechanics***. Tata McGraw Hill.

Reference Books:

1. R.W. Fox, P.J. Pritchard and A. T. McDonald. ***Introduction to Fluid Mechanics***. Wiley.
2. Frank M. White. ***Fluid Mechanics***. McGraw Hill.
3. G.K. Batchelor. ***An Introduction to Fluid Dynamics***. Cambridge University Press.
4. James E. A. John and William L. Haberman. ***Introduction to Fluid Mechanics***. Prentice Hall.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. gain basic understanding of boundary layer theory for various practical application of fluid flow in various regimes.
2. understand ideal fluid flow, compressible fluid flow and its applications.
3. learn the principle of dimensional analysis
4. get basic understating of unsteady flow and its application in water hammer.
5. gain basic knowledge of fluid machineries and its components.

ME 208 Mechanics of Solids L T P C

B. Tech (Mechanical Engg.) Fourth Semester (Core) 3 1 0 4

Unit-1 Concept of stress and strain: Definition of Simple stresses and Strains, properties of materials, constitutive relationship, deformation of axially loaded bars, members with varying cross section, composite bars, thermal stress, Saint-Venant's Principle, stress concentration, lateral strain, Poisson's ratio, volumetric strain, elastic constants and their relationship, Strain energy, Concept of stress and strain tensor, generalized Hooke's law.

Unit-2 Transformation of stresses and strains: Stresses on inclined plane, Mohr's circle, principal plane, principal stresses, transformation of stress and strains in a plane, principal strains, Mohr's Circle of stress and strains.

Unit-3 Stresses in beams: SF and BM diagrams for cantilever, simple supported and overhanging beams, Relationship between rate of loading, SF and BM. Theory of bending, assumptions, neutral axis and moment of resistance, bending stresses in symmetrical sections, section modulus, composite

beams.

Unit-4 Shear stress distribution: rectangular, circular, I- section and and T- section Torsional stresses in shafts: Analysis of torsional stresses, power transmitted Combined Stresses: Combined bending and direct Stresses, resultant stresses for column of different sections subjected to eccentric load, limit of eccentricity for no tension, combined bending and torsion

Unit-5 Deflection of beams: Relationship among curvature, slope and deflections, slope and deflection for Cantilever and S. S beams, Machaulay's method.

Unit-6 Theories of failures: Significance, failure theories for ductile and brittle materials, Tresca Criterion, Von-Mises Yield criterion, Mohr's Theory. Failure due to creep and fatigue.

Text Books:

1. Rattan. ***Strength of Material***. McGraw-Hill Education.
2. Beer & Johnson. ***Mechanics of Materials***. Tata McGraw-Hill, New Delhi**.**
3. Timoshenko. ***Strength of Materials Part- 1 & 2***.

Reference Books:

1. E P Popov. ***Engineering Mechanics of Solids***. PHI.
2. Pytel & Singer. ***Mechanics of Materials***. Harper Collins Publishers India Pvt. Ltd., New Delhi.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand, comprehend and analyze stresses, strains and its transformation.
2. determine stress-strain relations for linearly elastic members using theories of failures.
3. analyze mechanical structures using Shear force and bending moment.
4. determine and analyze the deflection of beams, combined stresses, torsion for engineering problems.

ME 209 Instrumentation and Measurement L T P C

B. Tech (Mechanical Engg.) Fourth Semester (Core) 3 0 0 3

Unit-1 Instruments and Their Representation: Introduction; Typical applications of

instrument systems; functional elements of a measurement system; classification of instruments; standards and calibration. Static and Dynamic characteristics of Instruments: Introduction; Accuracy, Precision; Resolution; Threshold; Sensitivity; Linearity; Hysteresis; Dead Band; Backlash; Drift; Formulation of Differential Equations for Dynamic Performance- Zero Order, First Order and Second order systems; Response of First and Second Order Systems to Step, Ramp, Impulse and Harmonic Functions.

Unit-2 Transducer Elements: Introduction; Analog and digital transducers; electromechanical, potentiometric, inductive self-generating and non-self-generating type transducers; electromagnetic, electrodynamics, eddy current, magnetostrictive, variable inductance, LVDT, variable capacitance and piezoelectric transducer; unbounded and bounded resistance strain gages; strain gage bridge circuits; single double and four active arm bridge arrangements; temperature compensation; balancing and calibration; ionisation transducers; mechano electronic transducers; opto-electrical transducers; photo conductive transducers; photovoltaic transducers; digital transducers; frequency domain transducer; vibrating string transducer; binary codes; digital encoders.

Unit-3 Motion, Force and Torque Measurement, Introduction; Relative motion measuring devices; electromechanical, optical, photo electric, moire-fringe, pneumatic and absolute motion devices; seismic devices; spring mass & force balance type device and their calibration; hydraulic load cell; pneumatic load cell; elastic force devices; separation of force components; electro mechanical methods; strain gauge; torque transducer; toque meter.

Unit-4 Indicating and Recording Elements: Introduction Amplifiers; Mechanical, Hydraulic, Pneumatic, Optical and Electrical Amplifying elements; Compensators; Differentiating and Integrating Elements; Cathode Ray Oscilloscope (CRO).

Unit-5 Pressure and Flow Measurement : Introduction; Moderate Pressure Measurement; Manometers; Elastic Transducer; Dynamic Effects of Connecting Tubing; High Pressure Transducer; Low Pressure transducer; Calibration and Testing; Quantity Meters; Positive Displacement Meters;

Flow Rate Meters; Variable Head Meters; Variable Area Meters; Rotameters; Pitot-Static Tube Meter; Drag Force Flow Meter; Turbine Flow Meter; Electronic Flow Meter; Electro Magnetic Flow meter; Hot-Wire Anemometer.

Unit-6 Temperature Measurement : Introduction; Measurement of Temperature; Non Electrical Methods – Solid Rod Thermometer, Bimetallic Thermometer, Liquid-in-Glass thermometer and Pressure Thermometer, Electrical Methods – Electrical Resistance Thermometers, Semiconductor Resistance Sensors (Thermistors) and Thermo–Electric Sensors; Thermocouple Materials; Radiation Methods-Total Radiation Pyrometer and Selective Radiation Pyrometer.

Text Books:

1. Ernest O. Doebelin. ***Measurement systems Application and Design***. Tata McGraw Hill Edition (2002).
2. Francis S. Tse and Ivan E. Morse, Marcel Dekker. ***Measurement and Instrumentation in Engineering***.
3. Alan S. Morris. ***Principles of Measurement and Instrumentation***. Prentice Hall of India.

Reference Books:

1. T.G. Beckwith, W.L. Buck and R.D. Marangoni. ***Mechanical Measurements***.
2. B.C. Nakra and K.K. Chaudhary. ***Instrumentation, Measurement and Analysis***. TMH.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. identify the fundamental theory of instrumentation.
2. correlate the theory of instrumentation with research and development and with the industrial situations.
3. know the fundamental theory for instrumentation.
4. prepare themselves for higher level instrumentation courses.

ME 210	Machining and Machine Tools	L T P C
	B. Tech (Mechanical Engg.) Fourth Semester (Core)	3 0 0 3

Unit-1 Introduction: Introduction to machine tools, motions of machine tools, generation of surfaces, types of machine tools, basic elements of machine tools. Lathe: Principle, classification, specifications, and operations performed on a lathe, estimation of machining time, machining parameters, and effects of process parameters on machining performance, lathe accessories.

Unit-2 Capstan and Turret Lathes: Introduction, comparison among capstan, turret and engine lathe, turret indexing mechanism, feeding mechanism, cutting tools and tool holders, turret tooling layout.

Unit-3 Shaper: Principle, classification, specifications, shaper mechanisms – crank and slotted lever quick return mechanism, feed mechanism, operations performed on shaper – machining horizontal, vertical, angular surfaces, cutting slots, grooves, key ways, machining irregular surfaces, splines and gears, calculation for machining time for shaping operations, effect of parameters on machining. Planer: Principle, classification, specifications, comparison between shaper and planer.

Unit-4 Milling machine: Principle, classification, specifications, peripheral milling, up and down milling, face milling, end milling, different operations performed on milling machines, dividing heads, methods of indexing – direct, simple, compound and differential indexing, milling of spur gear, milling cutters.

Unit-5 Drilling machine: Principle, classification, specifications, hole making operations performed on drilling machines, twist drill nomenclature.

Unit-6 Grinding machines: Principle, classification, specifications, different grinding processes, grinding wheel – components (wheel material), grit, grade and structure, specifications of grinding wheels. Glazing and loading in wheels, dressing, truing, balancing, and mounting of grinding wheels. Mechanics of Machining (Metal Cutting): Geometry of single point cutting tool, mechanism of chip formation and types of chips, use of chip breaker, orthogonal and oblique cutting, machining forces and Merchant's Circle Diagram (MCD), tool wear and tool failure, tool life estimation.

Text Books:

1. P N Rao. ***Manufacturing Technology Vol 2-Metal Cutting and Machine Tools***. Tata Mc Graw Hill.
2. A B Chattopadhyay. ***Machining and Machine Tools***. Willey.
3. G Boothroyd & W A Knight. ***Fundamentals of Machining and Machine Tools***. CRC Press Taylor & Francis Group.

Reference Books:

1. H Gerling. ***All About Machine Tools***. New Age Int. (P) Ltd.
2. A. Ghosh & A. K. Mallik. ***Manufacturing Science***. Affiliated East-West Press Pvt. Ltd
3. S K Hajra Choudhury. ***Workshop Technology Vol II Machine Tools.*** Media Promoters & Publishers Pvt. Ltd.
4. B S N Parashar. ***Elements of Manufacturing Processes***. PHI.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. have a general idea of machine tools and their uses.
2. identify and select different machine tools for practical applications.
3. select machining parameters and estimate the machining time.
4. classify the machining operations and prepare process plans.
5. employ machining processes for product development.
6. correlate the general concept of metal cutting to various machining operations.

ME 217 Energy Science and Technology L T P C

B. Tech (Mechanical Engg.) Fourth Semester (Core) 3 0 0 3

Unit-1 Basics of energy: Different forms of energy, energy conversion process, indirect and direct energy conversion; Different energy sources; sun as the source of energy – photosynthesis - classification of energy sources.

Unit-2 Conventional energy source and systems: Types of conventional fuels-fossil fuel reserves and resources; overview of global/ India’s energy scenario, engines, power plants, various methods of power generation; Thermodynamic analysis of conventional power plants.

Unit-3 Non conventional Energy Sources:

Solar Energy- measurements and prediction - Solar thermal energy conversions systems: flat plate collectors; Principle of photovoltaic conversion of solar energy.

Wind Energy- Wind Resource: Meteorology of wind, India's wind energy potential and challenges -distribution across the world; Wind measurement systems; Wind Energy Conversion Systems.

Bio-energy- Biomass as energy resources; Classification and estimation of biomass; Source and characteristics of biofuels; Biodiesel; Bioethanol; Biogas; Waste to energy conversions.

Geothermal Energy- Geothermal sources; advantages and disadvantages of geothermal energy over other energy forms; Geothermal energy in India; Prospects - Applications of Geothermal energy.

Unit-4 Energy Conservation and environment: Energy Conservation Act-2001 and its features - Electricity Act – 2003 and its features ;Framework of Central Electricity Authority (CEA); Central & States Electricity Regulatory Commissions (CERC & ERCs); Role of MoP (Ministry of Power)-BEE (Bureau of Energy Efficiency).

Energy and environment correlations, Environmental degradation due to energy production and utilization, global warming; Environmental Impact Assessment, Life cycle analysis (LCA) and sustainability issues.

Text Books:

1. J. Goldemberg, T.B. Johansson, A.K.N. Reddy and R.H. Williams. ***Energy for a Sustainable World.*** Wiley Eastern, 1990.
2. A.W. Culp. ***Principles of Energy Conversion***. McGraw Hill International edition, BEE Reference book: no. 1/2/3/4
3. D. A. Spera. ***Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering***, ASME Press.

Reference Books

1. S.P. Sukhatme. ***Solar Energy: principles of Thermal Collection and Storage***, Tata McGraw-Hill (1984).
2. B L Theraja. ***Fundamentals of Electrical Engineering and Electronics***, S Chand Pub.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand about the various energy systems and their relative merits and demerits.
2. understand the optimize way of utilizing new and renewable energy sources for sustainable development of the country.
3. quantify the scale of local and global energy utilization.
4. carry out research investigation and development work to solve practical problems.
5. understand the physical and chemical factors defining the carbon cycle and be able to relate these to global climate change, and to the readiness of carbon capture and storage technologies.
6. develop ability to Find out a solution to overcome emissions and economical challenges related to different energy systems.

ME 214 Material Testing Lab L T P C

B. Tech (Mechanical Engg.) Fourth Semester (Core) 0 0 3 2

Unit-1 Determination of tensile strength of ductile materials, Determination of compressive strength of brittle materials.

Unit-2 Determination of harness of materials, Determination of fatigue strength and torsional strength of materials.

Unit-3 Determination of lattice parameters of crystal lattice

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. determine the tensile strength of ductile materials.
2. determine compressive strength of brittle materials.
3. determine fatigue strength of materials.
4. determination of torsional strength of materials.
5. determination of hardness of materials.
6. determine lattice parameters of crystal lattice.

ME 215 Instrumentation and Measurement Lab L T P C

B. Tech (Mechanical Engg.) Fourth Semester (Core) 0 0 3 2

Unit-1 The following topics will be practically demonstrated to the students and

students will perform experiments on the available laboratory facilities related to instrumentation and measurement.

Unit-2 Pressure measurement, strain measurement, load measurement, water level measurement, temperature measurement, rotary measurement, flow measurement.

Unit-3 Capacitive pick trainer, inductive pickup trainer. Apart from these the students will also do practical on various trainer kit available for measurement of various physical parameters.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. experience different devices for measurement of various physical parameters
2. experience working of various sensors and actuators for different measurement devices.
3. learn through hands on training for selecting different devices for measurement of physical parameters.

ME 216 Thermo-Fluid Lab-II L T P C

B. Tech (Mechanical Engg.) Fourth Semester (Core) **0 0 3 2**

Unit-1 Determination of air fuel ratio in a four stroke diesel engine, plotting valve timing diagram in four stroke diesel engine,

Unit-2 Determination of COP and its variation with different operating condition, Determination of isothermal efficiency of reciprocating air compressor

Unit-3 Experimentation on open cycle gas turbine, thermal performance of solar energy systems

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. plot valve timing diagram in four stroke diesel engine.
2. determine air fuel ratio of 4S engine.
3. determine COP and its variation with different operating condition.
4. determine isothermal efficiency of reciprocating air compressor .
5. evaluate the thermal performance of various solar energy systems.

ME 301	Heat Transfer	L T P C
	B. Tech (Mechanical Engg.) Fifth Semester (Core)	3 1 0 4

Unit-1 Introduction: Heat transfer and its basic modes, governing laws, thermal properties of matter. General Heat Conduction Equation: Derivation of the generalized 3D heat conduction equation steady-state one-dimensional heat conduction in slab, cylinder, sphere and composite medium (i) with and without heat generation and (ii) with and without varying thermal conductivity, concept of critical thickness of insulation, concept of contact resistance.

Unit-2 Extended Surfaces or Fins: Classification, straight, rectangular and circular fins, temperature distribution and heat transfer calculations, fin efficiency, effectiveness, and applications. Transient Heat Conduction: definition, lumped capacitance analysis, applicability of lumped capacitance method.

Unit-3 Convection: Application of dimensional analysis to free and forced convection, significance of different dimensionless parameters, energy equation. Forced Convection over Exterior Surfaces: Boundary layer theory, velocity and thermal boundary layers, boundary layer equations, Reynolds's analogy, integral and similarity solutions to boundary layer equations, correlation for turbulent flow heat transfer.

Unit-4 Forced Convection In Internal Flows: concept of thermally fully developed flow, axial distribution of bulk mean temperature and wall temperature for uniform heat flux and wall temperature cases, calculation of Nusselt number for thermally fully developed Poiseuille flow, heat transfer for Couette flow with viscous dissipation effect, correlations for turbulent flow heat transfer.

Unit-5 Heat transfer in boiling and condensation: Introduction to boiling, different regime of pool boing curve, Introduction to film and dropwise condensation, Nusselt's classical theory for film condensation. Heat Exchangers: Definition, classification, LMTD method, effectiveness - NTU method.

Unit-6 Thermal Radiation: Fundamental principles, total and spectral emissive power and intensity of radiation, concept of black body, Planck's law, Wien's, displacement law, Stefan-Boltzmann law, black body radiation function, concept of grey, opaque, and transparent bodies, emissivity and Kirchhoff's laws, view factor, net radiation exchange in a two-body

enclosure, radiation shield.

Text Books:

1. M. Necati Ozisik. ***Heat Transfer: A Basic Approach***. McGraw Hill Publication.
2. F. P. Incropera, D. P. Dewitt, T.L. Bergman, A. S. Lavine***, Principles of Heat and Mass Transfer***. John Wiley & Sons.
3. S K Som. ***Introduction to Heat Transfer***. Prentice Hall.

Reference Books:

1. Y. A. Cengel, A. J. Ghajar. ***Heat & Mass Transfer***. McGraw-Hill Publishers.
2. P. K. Nag. ***Heat and Mass Transfer***. McGraw-Hill Publishers.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. analyse problems involving steady state heat conduction in simple geometries.
2. evaluate the rate of heat transfer for forced convection over exterior surfaces and inside ducts.
3. solve problems involving boiling and condensation.
4. analyse heat exchanger performance by using the method of log mean temperature difference and effectiveness- NTU.
5. calculate radiation heat exchange between black body surfaces and grey body surfaces.

ME 302 Machine Design - I L T P C

B. Tech (Mechanical Engg.) Fifth Semester (Core) 3 1 0 4

Unit-1 Introduction to Mechanical Engineering Design: Mechanical engineering design, design standards, stress and strength, static and dynamic loading, parameters influencing design and factor of safety, general three-dimensional stress, elastic strain, stress concentration, strain energy, failure theories, maximum-shear-stress theory, distortion-energy theory, Coulomb-Mohr theory, maximum-normal-stress theory, modifications of the Mohr theory, selection of failure criteria, key problems on failures resulting from static loading, overview on design for manufacturing assemblies.

Unit-2 Fatigue Failure: Introduction to fatigue in metals, approach to fatigue failure in analysis and design, Goodman, modified-Goodman and Soderberg criteria., the endurance limit, fatigue strength, S-N Diagram, endurance limit

modifying factors, stress concentration and notch sensitivity, fatigue failure criteria for fluctuating stress, torsional fatigue strength under fluctuating stresses, combinations of loading modes, varying, fluctuating stresses; cumulative fatigue damage.

Unit-3 Shafts, Keys and Pins: Shaft materials, shaft design for stress and deflection, critical speeds for shafts, shafts subjected to twisting moment, bending moment, combined twisting and bending moment, fluctuating loads, axial load in addition to combined torsion and bending loads, design of keys and pins, types of keys, stresses in keys, design of square, rectangular and taper keys.

Unit-4 Permanent and Temporary Joints: Design of riveted joint: types of riveted joints, its failure, strength and efficiency, design stresses, structural joints of butt and lap type, bolted joints, rivets subjected to eccentric loading; Cotter and knuckle joints: design of socket and spigot cotter joints, cotter joint for strap end of a connecting rod, Gib and cotter joint for square rods, knuckle joint; Welded joints: strength of welds, eccentric load in plane of weld, welded pressure vessel and some practical applications.

Unit-5 Screws, Fasteners, Spline and Couplings: Stresses in bolts, effect of initial tension, bolts under dynamic and impact loading, eccentric loading, power screws, form of threads, force analysis, screw and nut design, differential and compound screws, stresses in power screws, screw clamp and nut, design of screw jack, introduction to turnbuckle, design of turnbuckle, design of rigid flange coupling, design of flexible coupling.

Text Books:

1. Bhandari. ***Design of Machine Elements***. McGraw-Hill Publishers, 2/e.
2. Shigley. ***Mechanical Engineering Design***. McGraw Hill Publishers, 9/e.
3. Sharma & Agarwal. ***Machine Design***. S K Kataria and Sons

Reference Books:

1. Mahadevan K, Reddy. ***Design Data Handbook***. KB, CBS, New Delhi.
2. Spotts. ***Design of Machine Members***. Prentice Hall Publishers.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand the fundamental design process and correlate with the engineering applications.
2. apply the fundamentals of stress analysis, theories of failure and material science in the design of machine components.
3. demonstrate the preceding abilities by performing correctly: the design, analysis and sizing of machine components.
4. design keys, cotters, couplings and joints including riveted, bolted and welded joints.

ME 303	Turbomachinery	L T P C
	B. Tech (Mechanical Engg.) Fifth Semester (Core)	**3 1 0 4**

Unit-1 Introduction: Impulse-momentum principle, definition of a turbo-machine, fundamental theory of turbo-machines, and classification of turbo machines.

Unit-2 Hydraulic Turbines: Introduction, classifications of hydraulic turbines, concepts of heads of turbines, concept and definitions of efficiencies of turbines. Impulse turbines- main components of Pelton turbines, design of components of Pelton turbines, force, power and efficiency of Pelton turbine. Reaction Turbines- Main components of modern Francis turbine, design of components of Francis turbine, torque, power and efficiency of Francis turbine, components and design of propeller and Kaplan turbines. Draft tube, function and efficiency of draft tube, types of draft tube, governing of hydraulic turbines, specific speed, performance characteristic curves of turbines, model selection and performance of turbines, cavitation of turbines.

Unit-3 Centrifugal Pumps: introduction, main components of centrifugal pumps, definitions of head and efficiency of a centrifugal pump, working principle, priming of centrifugal pump, multistage centrifugal pumps, specific speed, performance characteristic curves of pumps, selection and performance of a centrifugal pump, cavitation in pump, operational difficulties in centrifugal pumps, axial flow pumps.

Unit-4 Steam Turbines: introduction, working principle of steam turbine, classification of steam turbine, simple impulse turbine, compounding of steam turbine, pressure compounded impulse turbine, velocity compounded impulse turbine, pressure-velocity compounded impulse turbine, flow

through impulse turbine blades, velocity triangle, work done, power and efficiencies, blade sections, flow through impulse reaction turbine blades, velocity triangles, work done, efficiencies, degree of reaction, Parson's Turbine, blade sections, governing of steam turbines, losses of steam turbines, state point locus, reheat factor, turbine efficiency parameters.

Unit-5 Compressors, Fan and Blower: Introduction, classification of compressors, basic components, principle of working, velocity triangles, enthalpy-entropy diagram, performance coefficients, effect of impeller blade shape on performance, vanned and vaneless diffuser, efficiency, degree of reaction, issues and challenges- stalling, surging, choking, slip, centrifugal fan, impeller, performance and point of operation, blade profiles, performance of blowers.

Text Books:

1. Ganesan. ***Gas Turbine***. McGraw-Hill Education, 3/e.
2. Jagdish Lal. ***Hydraulic Machines***. Metropolitan Publication.
3. R. Yadav. ***Steam & Gas Turbine and Power Plant Engineering***. Central Pub. House.

Reference Books:

1. R. K. Bansal. ***A Test Book of Fluid Mechanics and Hydraulic Machines.*** Laxmi Pub.
2. S. L. Dixon. ***Fluid Mechanics and Thermodynamics of Turbomachinery***. Butterworth-Heinmann.
3. Earl Logan Jr. ***Turbomachinery***. Marcel Dekker Inc.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. recognize different turbo machineries and their applications.
2. design different turbo machineries.
3. analyse different turbo machineries.
4. synthesize the operations of turbo machineries.

ME 304	Advanced Solid Mechanics	L T P C
	B. Tech (Mechanical Engg.) Fifth Semester (Core)	3 1 0 4

Unit-1 Energy Methods: Principle of superposition, Work done by forces and elastic strain energy stored, Rayleigh's method, Maxwell-Betti-Rayleigh Reciprocal theorem, Beggs Deformeter, First theorem of Castigliano, Principles of virtual work, Kirchhoff's theorem.

Unit-2 Thick and Thin cylinders: Derivation and solution of differential equations of equilibrium, stresses produced by shrink fit, compound cylinders.

Unit-3 Rotating rims and discs: Stresses on thin rotating rims and rotating discs of uniform thickness, derivation, solution of differential equations rotating discs of variable thickness, stresses in flywheel.

Unit-4 Columns and struts: Definition, basic structures, Euler's Equation and Rankine's formula. Curved beams: Difference between straight and curved beam theories, pure bending of curved beams, Winkler Back theory, bending of curved beams by forces acting in the plane of symmetry, particular cases of curved beam sections.

Unit-5 Unsymmetrical bending: Product second moment of area, principal second moment of area, Mohr's circle of second moment of areas, determination of resultant stresses at a point, orientation of neutral axis, cases of symmetrical and unsymmetrical sections, shear center.

Unit-6 Introduction to Fracture mechanics: Basic concept and significance of fracture mechanics theory (LEFM and EPFM), fracture parameters and applications.

Text Books:

1. L. S. Srinath. ***Advance d Mechanics of Solids***. TMH.
2. S. S. Rattan. ***Strength of Material***. McGraw-Hill.
3. Beer & Johnston. ***Mechanics of Materials***. Tata McGraw-Hill.

Reference Books:

1. Roy R. Craig, Jr. ***Mechanics of Materials***. John Whiley.
2. Krishnaswamy, Kulkarni & Gharpure. ***Advanced Strength of Materials***. Khanna Publishers.
3. E. P. Popov. ***Mechanics of Materials***. Pearson.
4. Krishna Raju & Gururaja. ***Advance Mechanics of Solids & Structures***. Narosha Publishing House.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand and analyse thick cylinders, rotating disc.
2. analyse mechanical components or structures by using energy methods.
3. determine stress-strain relations for linearly elastic members using theories of failures.
4. design straight beams, curved and asymmetrical bending of beams.
5. apply shear center of beams, torsion and axi-symmetric problems.
6. understand the basics of fracture mechanics and finite element methods.

ME 305 IC Engine L T P C

B. Tech (Mechanical Engg.) Fifth Semester (Core) 3 0 0 3

Unit-1 Air Standard Cycles: Review of Carnot cycle, Otto cycle, diesel cycle, limited pressure cycle, Stirling cycle, and other cycles; Actual cycles: various losses in actual cycles, effect of operating variables, reasons for deviation of actual cycle from air standard cycles. Introduction to Engine: Introduction of internal and external combustion engine and their comparison, four stroke cycle S.I. and C.I. engine, two stroke engine, comparison of four stroke and two stroke engines, comparison of S.I. and C.I. engine, classification of I.C. engine.

Unit-2 Fuels: Basic requirement of I.C. engine fuels, requirement of an ideal gasoline, structure of petroleum, effect of fuel structure on combustion, properties of CI and SI engine fuels. Carburetion: Properties of air-petrol mixtures, mixture requirement, simple carburetor, limitation of simple carburetor, modern carburetor, main metering system, idling system, economizer system, acceleration pump and cold starting system, nozzle lip, venturi depression, calculation of fuel jet and venturi throat diameter for given air fuel ratio, petrol injection system, electronic fuel injection, advantage and disadvantage of petrol injection, multi-point fuel injection system.

Unit-3 Fuel Injection: Requirement, type, air injection system, solid injection system, fuel pump, type of fuel injector, type of nozzle, atomization, spray penetration and spray direction, common rail system, injection pump, nozzle, quantity of fuel and size of nozzle orifice, injection advancement.

Ignition System: battery and magneto ignition system and their comparative study, spark plug, electronic ignition system, firing order, ignition timing, ignition advancement, centrifugal and vacuum ignition advance.

Unit-4 Combustion in IC Engine: Normal and abnormal combustion in SI engines including pre ignition and knock, P-Theta diagram, methods to prevent abnormal combustion in SI engines, SI engine combustion chambers, normal and abnormal combustion in CI engines, P-Theta diagram, types of CI engine combustion chambers.

Unit-5 Cooling System: Cooling requirement, air cooling, liquid cooling, type of liquid cooling system, advantage and disadvantage of air cooling and water cooling system, and antifreeze mixture. Lubrication System: Function of lubricating system, properties of lubricating oil, types of lubrication system, lubricating oil, properties of lubricants, types, and grades of lubricating oil.

Emission and Pollution: SI engine and CI engine emissions and its control and comparison, effect of pollution on human health and bio sphere, catalytic converters.

Unit-6 Engine Performance and Testing: William`s line method, Morse test, motoring test, retardation test, Prony brake, rope brake, hydraulic dynamometer, emission, fuel consumption, volumetric type flow meter, effect of valve timing and engine speed on volumetric efficiency fuel consumption and air consumption measurements, combustion phenomenon, performance parameters and characteristic, engine heat balance.

Text Books:

1. John B Heywood. ***Internal Combustion Engine Fundamentals***.
2. Charles Fayette Taylor. ***The Internal Combustion Engine in Theory and Practice:*** *Vol. 1 & 2*.
3. Willard W. Pulkrabek. ***Engineering Fundamentals of the Internal Combustion Engine***.

Reference Books:

1. Gill P W., J H. Smith, E J. Ziury. ***Fundamentals of Internal Combustion Engines***.
2. V Ganesan. ***Internal Combustion Engines***.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. differentiate among different internal combustion engine designs.
2. recognize and understand reasons for differences among operating characteristics of different engine types and designs.
3. understand the engineering systems needed to set-up and run engines in controlled laboratory environments.
4. develop skills to run engine dynamometer experiments.
5. compare and contrast experimental results with theoretical trends, and to attribute observed discrepancies to either measurement error or modelling limitations.
6. develop an appreciation for theoretical and practical limits to engine performance and fuel economy through the use of both theoretical techniques and experimentation.

ME 306 Advanced Manufacturing Process L T P C

B. Tech (Mechanical Engg.) Fifth Semester (Core) 3 0 0 3

Unit-1 Introduction: Introduction to new methods of production and their importance. Advanced Casting Processes: Permanent mould casting, ceramic mould casting, plaster mould casting, investment casting, ceramic shell investment casting, vacuum casting, continuous casting, evaporative pattern casting, squeeze casting their process principles and applications.

Unit-2 Advanced Forming Processes: Shape rolling operations like ring rolling, thread rolling, rotary tube piercing; precision forging, heading, hubbing, roll forging, skew rolling, orbital forging, incremental forging, isothermal forging, stretch forming, contour roll forming, rubber forming, spinning, superplastic forming, HERF like explosive forming, magnetic-pulse forming, electro hydraulic forming, laser assisted forming, liquefied gas forming, their process principles and applications.

Unit-3 Advanced Welding Processes: Plasma-arc welding (PAW), thermit welding (TW), electron-beam welding (EBW), laser-beam welding (LBW), ultrasonic welding, friction welding, friction stir welding, resistance welding, explosive welding, diffusion welding, their process principles and applications.

Unit-4 Advanced Machining Processes: Classification and selection of non-

traditional machining technologies, non-traditional processes- WJM, AJM, AWJM, USM, ECM, CHM, EDM, EBM, LBM, PAM- Parameters, responses, mechanism and analysis, effect on material, applications, economics and selection of process; Hybrid processes.

Unit-5 Modern Trends in Manufacturing: Introduction to micro-manufacturing, micro/nano finishing, micro-elctro-mechanical systems (MEMS), their process principle and applications, basic concept of nanomaterials, their properties, synthesis strategies and applications.

Unit-6 Rapid Prototyping (RP): Importance of RP, introduction of solid-based, liquid-based, powder-based RP processes.

Text Books:

1. Schey. ***Introduction to Manufacturing Processes***. McGraw-Hill Publisher.
2. S. Kalpajjian, S.R. Schmid. ***Manufacturing Engineering & Technology***. Pearson education (Singapore) Pvt. Ltd.
3. E. P. DeGarmo, J. T Black, R. A. Kohser. ***Materials and Processes in Manufacturing (8th Edition)***. Prentice Hall of India, New Delhi.

Reference Books:

1. Ghosh, and A. K. Mallik. ***Manufacturing Science***. Affiliated East-West Press Pvt. Ltd., New Delhi.
2. P. K. Mishra. ***Non-Conventional Machining***. Narosa Publishers.
3. G.F. Benedict, Marcel Dekker. ***Nontraditional Manufacturing Processes***.
4. N. P. Mahalik. ***Micromanufacturing and Nanotechology***. Springer.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. apply the working principles and processing characteristics of non-traditional machining to the production of precision components.
2. select non-traditional machining parameters and estimate surface roughness.
3. recommend appropriate part manufacturing processes using advanced casting, forming and welding processes when provided a set of functional requirements and product development constraints.
4. employ micro-manufacturing processes and nanotechnology for product development.

ME 311 Fluid Machinery Lab L T P C

B. Tech (Mechanical Engg.) Fifth Semester (Core) **0 0 3 2**

Unit-1 Determination of power and efficiency of various hydraulic turbines with different discharge and head conditions.

Unit-2 Determination of the efficiency of centrifugal pump under different head conditions.

Unit-3 Plotting of performance characteristics of the hydraulic turbines and the pumps.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. determine the efficiency of various hydraulic machines under varied operating conditions.
2. plot performance characteristics of hydraulic machines and able to analyse their performance.

ME 312 Machining Lab L T P C

B. Tech (Mechanical Engg.) Fifth Semester (Core) **0 0 3 2**

Unit-1 Conventional Machines And Machine Tool: Lathe, milling, shaper, drilling etc. Lathe: turning, tapper turning, thread cutting, drilling etc.

Unit-2 Milling: Introduction to cutting tools for milling and their application; Face milling, gear cutting; Utilization of other machines like drilling, shaper, planner etc.

Unit-3 Advanced Machining Process: Experimental investigation of electric discharge machining (EDM), wire EDM, ultra-sonic machining (USM), photo chemical machining (PCM) etc., machining parameters and their effect on work piece.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. identify different machine tool, their accessories and mounting
2. operate conventional machine tool and machines.
3. select the machine input parameters required for machining process.
4. identify the suitable advanced machining process required for production.

5. select input parameters for advanced machining process.
6. produce desire components/product using advance machining process.

ME 313	Heat Transfer Lab	L T P C
	B. Tech (Mechanical Engg.) Fifth Semester (Core)	0 0 3 2

Unit-1 Determination of thermal conductivity of metal, Analysis in both steady and transient heat conduction, radial and linear heat conduction.

Unit-2 Determination of emissivity of the test plate at various temperatures and plot the graph of Emissivity vs. Temperature, Determination of energy transfer by radiation.

Unit-3 Determination of average heat transfer coefficient in forced convection apparatus at different flow rates and heat inputs, Determination of LMTD, Heat transfer rate and overall heat transfer coefficient for various heat exchangers such as parallel flow, counter flow, cross flow, shell and tube.

Unit-4 Determination of heat transfer rate in a pin fin apparatus.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. determine the thermal conductivity of metal.
2. analyse both steady and transient, linear and radial heat conduction.
3. determine the of emissivity of the test plate at various temperatures and plot the graph of emissivity vs. temperature.
4. determine the rate of radiative energy transfer.
5. determine average heat transfer coefficient in forced convection apparatus at different flow rates and heat inputs.
6. calculate LMTD, rate of heat transfer rate and overall heat transfer coefficient for various heat exchangers such as parallel flow, counter flow, cross flow, shell and tube etc.
7. evaluate the rate of heat transfer through pin fins and plot temperature distribution along the fin length.

ME 307	Machine Design-II	L T P C
	B. Tech (Mechanical Engg.) Sixth Semester (Core)	3 1 0 4

Unit-1 Flexible Mechanical Elements: Introduction, mechanics of belt drive, belt materials, selection of a pulley, design of flat and round-belt-pulley drive assembly, design of V-belts, timing belts, design of roller chain and sprocket assembly.

Unit-2 Clutches and Brakes: Clutches: positive and frictional clutches, plate friction or disc clutches, cone clutches. Brakes: block brakes, band brakes, disc brakes (internal expanding and external contacting shoe).

Unit-3 Design of Gears: Types of gear, involute and cycloidal properties, contact ratio, interference, the forming of gear teeth, tooth systems , gear trains, force analysis—spur gearing, force analysis-helical gearing, the Lewis bending equation and form factor, velocity factor, Barth`s formula, working stresses in gear teeth, dynamic loads on gear teeth, design of spur gear for wear, virtual number of teeth in helical gears, beam strength and wear strength of helical gears, design of helical gears.

Unit-4 Design of Mechanical Springs and Pressure Vessel: Introduction and classification, application of springs, stresses in helical springs, the curvature effect, deflection of helical springs, compression springs, stability, spring materials, helical compression spring design for static service, critical frequency of helical springs, fatigue loading of helical compression springs, helical compression spring design for fatigue loading, fundamental and design of pressure vessel.

Unit-5 Bearings: Introduction to Bearing design, it's applications, classifications and its' pros and cons, Petroff's equation, Selection of bearing, theory of lubrication, Hydrodynamic bearing, Hydrostatic bearing and Anti-friction bearings, Reynold's equation, Significance of load bearing capacity, Sommerfeld number and eccentricity, Heat balance of bearing, Modes of failures in bearings, Mechanical aspects of bearing design, Stribeck Equation, Ball bearing design, Load and life of bearings, Equivalent bearing load, Load-life relations, Reliability of bearing.

Text Books:

1. V.B. Bhandari. ***Design of Machine Elements***. McGraw-Hill Publishers, 2/e.

2. Shigley.***Mechanical Engineering Design***. McGraw Hill Publishers, 9/e.
3. Sharma and Agarwal.***Machine Design***. S. Chand & Co.

Reference Books:

1. Mahadevan K and Reddy.***Design Data Handbook***. KB, CBS, New Delhi.
2. Spotts.***Design of Machine Members***. Prentice Hall Publishers

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. acquire fundamental knowledge of mechanical design procedure.
2. describe the type of loading considering stress analysis and theories of failure.
3. derive and analyze the mode of failure and applied stresses in the components.
4. design, formulate and analyze the mechanical components such as bearing, gear, clutch, brake, spring and pressure vessel.

ME 308 Automobile Engineering L T P C

B. Tech (Mechanical Engg.) Sixth Semester (Core) 3 1 0 4

Unit-1 Introduction: Automotive Vehicles, Development, Layout and types of automotive vehicles- cars, buses, tractors, air cushion vehicles and off the road vehicles.

Unit-2 Chassis construction: The frame and its functions, layout of the components of transmission system in four-wheel rear drive vehicles.

Unit-3 Clutches: Purpose, requirements, relative merits and demerits of different types of clutches.

Transmission System: Purpose, sliding mesh gear box, constant mesh gear box, Power flow diagrams, torque converter, automatic transmission - an overview. Universal coupling, propeller shaft, final drive - types, functions. Differential - purpose, construction.

Unit-4 Suspension System: Basic requirements & Coordinate frames, function of suspension springs, types of suspensions, shock absorbers, stabilizer or anti-roll device, suspension mechanics: solid axle suspension, Independent suspension, roll centre and roll axis. Front axle and steering: Front axle, wheel geometry, factors of wheel alignment, steering geometry, angle,

mechanisms, cornering force, self- righting torque, under steer and over steer, steering gears & ratio, reversibility, power steering, steering dynamics: kinematic steering, vehicle with more than two axles, steering trouble shooting.

Unit-5 Brakes: Principle, braking requirements, brake efficiency and stopping distances, fading of brakes, weight transfer, wheel skidding, types of brakes, drum brakes-brake shoes, brake linings, disc brakes, mechanical brakes, hydraulic brakes, brake fluid, electric brakes, engine exhaust brakes, air brakes, hand brake, hill holding device, bleeding of brakes.

Unit-6 Tyres: Tyre types, relative merits and demerits, tyre dimensions and specifications, Ride characteristics of tyres, wheel hop, wheel wobble, wheel wander, wheel shimmy, behaviour while cornering, cornering force, power consumed by a tyre, effect of driving and braking torque, factors affecting tyre life, tread design.

Unit-7 Road Loads: Air resistance-Mechanics of air flow around a vehicle, pressure distribution on a vehicle, factors affecting rolling resistance, aerodynamic forces– aerodynamic drag, drag components, drag coefficient, aerodynamic aids, aerodynamic side force, lift force, pitching moment, yawing moment, rolling moment, cross wind sensitivity,

Body and safety considerations and modern developments in automobiles: Requirements of automobile body, materials for body work, rust protection, safety considerations & norms, crash worthiness, ABS Systems.

Text Books:

1. Crouse. ***Automotive Mechanics***.McGrawhill, New Delhi.
2. Heitner Joseph. ***Automotive Mechanics***. East West Press.
3. William H. Crouse and Donald L Anglin.***Automobile Engineering***.

Reference Books:

1. Kingston Forbes. The Principles of Automobile Body Design. Franklin Classics Trade Press.
2. Tom Denton. ***Automobile Mechanical and Electrical Systems*.** Taylor & Francis Ltd.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand the basics of automobile engineering and to be conversant with the different parts of an automobile.
2. develop competencies in performance analysis of a vehicle.
3. gain knowledge on vehicle safety and maintenance.
4. understand the emerging trends in automobile technology.

ME 309 Power Plant Engineering L T P C

B. Tech (Mechanical Engg.) Sixth Semester (Core) 3 1 0 4

Unit-1 Power Plant in General: Introduction to different power plants, Load duration curves, Location of power Plants, Power plant economics, Indian energy scenario.

Unit-2 Steam Power Plant: Introduction, Rankine cycle, Carnot cycle, Reheating of steam, Regeneration, Steam power plant appraisal, Deaeration, Typical layout of steam power plant, Efficiencies in steam power plant, Co generation of power and process heat, Combined cycle power generation, Different types of fuel used for steam Generation, Draught system, Classification of boilers, Boiler accessories, Classification of steam turbines and their working.

Unit-3 Gas Turbine Power Plant: Introduction, Classification of different gas turbine power plants, Analysis of closed cycle and open cycle constant pressure gas turbine plant, components of gas turbine plants.

Unit-4 Diesel Electric Power Plant: Introduction, Application of diesel engines in power field, Advantages and disadvantages of diesel engine power plant, General layout, Performance characteristics, Supercharging.

Unit-5 Hydro-Electric Power Plant: Introduction, Classification of hydro-electric power plant, Pumped storage plant, Site selection, Elements of hydro-electric power plant, Advantages of hydro-electric power plant, Classification of hydraulic turbines and its selection, Hydrographs, Flow duration curves.

Unit-6 Nuclear Power Plant: Introduction to nuclear engineering, Types of nuclear reactors, Pressurized water reactor, Boiling water reactor, CANDU reactor, Gas-cooled reactor, Liquid metal fast breeder reactor, India`s nuclear power

programme.

Unit-7 Non- Conventional Power plants: Prospect of renewable energy source, Types of non-conventional power plants, Solar plants, Wind power plants, Bio-mass plants, Geo-thermal power plant, Tidal power plant.

Text Books:

1. R. K. Rajput. ***Power Plant Engineering***. Laxmi Publication.
2. P. K. Nag. ***Power Plant Engineering***. Tata McGraw Hills.
3. V. Ganesan. ***Gas Turbine***. McGraw-Hill Education, 3/e.

Reference Books:

1. R. Yadav. ***Steam & Gas Turbine and Power Plant Engineering***. Central Pub. House.
2. Arora and Domkundwar. ***A course in Power Plant Engineering***. Dhanpat Rai & Sons.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. recognize various power plants designs, their equipment and devices.
2. describe the operation and maintenance of a power plant.
3. identify and select a proper power plant design & its equipment under any given operating condition and application.
4. develop sound knowledge and skills needed to be successful in industry or excel in research and also have a successful professional career.

ME 310 Dynamics and Control of Machinery L T P C

B. Tech (Mechanical Engg.) Sixth Semester (Core) 3 1 0 4

Unit-1 Static and dynamic force analysis: Static and dynamic force analysis: Introduction, Forces, moments and Couples, Static Equilibrium, Graphical Force Analysis, Analytical Approach to Force Analysis, Dynamic equilibrium of Systems of particles, Dynamic Equilibrium of System of rigid bodies, Dynamic analysis of slider crank mechanism, Engine force analysis, Turning moment on crank shaft, Turning moment diagrams and Flywheel, Gyroscope and gyroscopic effects, Cam Dynamics, Dynamical

analysis of cam and follower.

Unit-2 Vibration: One degree of freedom system, Free and forced vibrations of SDOF, Transverse and torsional vibration, effect of damping, Rotating and reciprocating unbalance, Resonance, Critical speed of shafts, Vibration isolation and measurements, Two degree of freedom systems, Vibration absorber, Multi degree of freedom system.

Unit-3 Control Engineering: Open and closed loop control, Block diagrams, Laplace transform, Mathematical model of physical system, Basic control action- pneumatic controller and hydraulic controller, Transient response of first order and second order system, Routh`s stability criteria, Sensitivity analysis, Frequency response analysis, Improving system performance, Introduction to non- linear control.

Text Book:

1. Norton.***Kinematics and Dynamics of Machinery (SIE)***, Mc Graw-Hill, 1/e.
2. Rattan. ***Theory of Machines.***Mc Graw-Hill, 3/e.
3. Gowda.***Mechanical Vibrations***. Mc Graw-Hill, 1/e.
4. J. S. Rao and R.V. Dukkipati.***Mechanism & Machine Theory***. New Age International Publication

Reference Books:

1. K. Ogata.***Modern Control Engineering.*** Prentice Hall International
2. B. C. Kuo.***Automatic Control System.*** Prentice Hall International.
3. A. Ghosh and A.K. Mallick.***Theory of Mechanisms & Machines***. Affiliated East West Press Pvt Ltd.
4. Kenneth J. Waldron and Gary L. Kinzel.***Kinematics, Dynamics and Design of Machinery***. Wiley India.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. gain the fundamental knowledge of static and dynamic force analysis.
2. learn the basics of mechanical vibration, classifications and its applications.
3. derive and analyse the dynamical governing equations and different modes of vibration.
4. gain the basic understanding of classifications and behaviour of control systems.

ME 314 Automobile Lab L T P C

B. Tech (Mechanical Engg.) Sixth Semester (Core) **0 0 3 2**

Unit-1 Constructional details, working principles and operation of Automotive Clutches.

Unit-2 Automotive Transmission systems. Automotive Drive Lines & Differentials.

Unit-3 Diesel and Petrol Engines. Engine cooling & lubricating Systems.

Unit-4 Automotive Suspension Systems, Automotive Steering Systems, Automotive Brake systems, Automotive Tyres & wheels.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. distinguish the various types of engine.
2. distinguish the various parts and systems of an automobile.
3. develop skills in dismantling & assembling of running system.

ME 315 Dynamics Lab L T P C

B. Tech (Mechanical Engg.) Sixth Semester (Core) **0 0 3 2**

Unit-1 Cam Analysis – Cam Profile and Jump-speed Characteristics.

Unit-2 Torsional vibration under viscous damping. Torsional vibration of two rotor system.

Unit-3 Determination of Gyroscopic Couple.

Unit-4 Experiment on Hartnell Governor.

Unit-5 Free Vibration of Spring Mass System – Determination of Natural Frequency.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. perform static and dynamic analysis of simple mechanisms.
2. model and analyse mechanical systems subjected to vibrations.
3. understand the implications of computed results in dynamics to improve the design of a mechanism.
4. analyse mechanical systems where the cam and governor used.

ME 316 Machine Design Lab L T P C

B. Tech (Mechanical Engg.) Sixth Semester (Core) **0 0 3 2**

Unit-1 Solutions of design problems and code generation / simulation / CAD modelling-

a) Design engineering component by Programming – MATLAB / C-language / Any other programming language

b) Application of solid modeling by using CATIA / SOLIDWORKS

c) Application of FEM by using ANSYS / ABAQUS / COMSOL / Any other simulation software

d) Application of optimization technique in engineering design

Unit-2 Design and analysis of prime mover.

Unit-3 Design and analysis of non-prime mover or innovative product.

Unit-4 Estimation and costing of a designed engineering component or assembly

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. learn the fundamental design procedure
2. plan, organize, coordinate, control and analyze the design route map
3. learn and comprehend the design optimization technique
4. design and analyse the prime mover / non-prime mover / innovative product
5. estimate and costing techniques of designed product or component

ME 331 Computer Numerical Control of Machine Tools L T P C

B. Tech (Mechanical Engg.) Sixth Semester (Deptt. Elective – I) **3 0 0 3**

Unit-1 Introduction, Fundamentals of Numerical Control (NC), Computer Numerical control (CNC), Direct Numerical control (DNC), comparison between conventional and CNC systems, Classification of CNC system, Design consideration in CNC machine tools, Industrial applications of CNC, Economic benefit of CNC.

Unit-2 System Devices: Drives, Feedback devices, Counting devices, Data Input Devices: Punched tape, Tape readers, Magnetic tape and discs, Manual data input, (MDI), Lead screws.

Unit-3 Control Systems: Fundamental problems of control, Position or point to point, straight line and contouring control, Machine tool control, Open and closed loop control, Adaptive Control system.

Unit-4 Interpolation: Digital differential analyzers (DDA) integrator, DDA hardware interpolator, CNC software interpolators, Software DDA interpolator, Linear and Circular interpolation.

Unit-5 NC Part Programming Concepts: NC coordinate system, Part programming terminology, preparatory and miscellaneous Codes, Part programming formats, procedures and methods, Manual programming, Computer aided programming, APT programming and practice.

Unit-6 Associated Systems of CNC: Introduction to Flexible manufacturing systems (FMS), CAD/CAM, Industrial robots, CIM systems.

Text Book:

1. Mehta. ***Machine Tools Design and Numerical Control***. McGraw-Hill, 3/e.
2. Yoram Koren. ***Computer control of manufacturing system.*** McGraw Hill Book Co.
3. B. L. Jones. ***Computer Numerical Control.*** John Wiley and Sons.

Reference Books:

1. Chen and Lin. ***Computer Numerical Control.*** Glory Educational Resource Inc.
2. Rao, Tiwari and Kunda. ***Computer Aided Manufacturing***. Tata McGraw Hill.
3. Groover and Zimmer. ***CAD/CAM***. PHI.
4. Groover. ***Automation Production systems and computer integrated manufacturing***. PHI
5. Chang, Wysk and Wang. ***Computer aided manufacturing***. PHI.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. identify the applications of CNC machines.
2. select and describe the working principles of various devices and equipment used in CNC.
3. develop the CNC part programs for machining various components and handle CNC machines.
4. correlate the CNC technology with other associated systems and automation.

ME 332 Diagnostic Maintenance of Mechanical Equipments L T P C

B. Tech (Mechanical Engg.) Sixth Semester
(Deptt. Elective – I) **3 0 0 3**

Unit-1 Introduction: Unplanned and planned maintenance – objectives of planned, preventive and predictive maintenance – conditioned based maintenance and signature analysis, concept of reliability, Availability and maintainability, Fault analysis planning – failure mode and effect analysis, fault tree analysis, case studies, applications in industry.

Unit-2 Maintenance: Basic definitions, preventive, operating and shutdown maintenance, level of maintenance, factor influencing Preventive Maintenance, data processing technique, focus on implementing with examples, measuring maintenance effectiveness and maintenance control.

Unit-3 Non-destructive testing: Its importance testing to maintenance, principal methods-dye penetrant, magnetic particle testing and ultrasonic tests, Tero-technological approach to maintenance. Fluid Condition and Contaminant

Unit-4 Analysis: Carrier fluid degradation, spectroscopy and spectrometric oil analysis procedure, Ferrography, Magnetic Chip detection. Visual testing, Liquid Penetrant inspection, X-ray photography, Application of ultrasonic and acoustic emission for fault detection.

Unit-5 Wear: Different types of wear and technique for minimisation of wear with examples: Diagnostic Data processing and decision making, statistical distribution, approach to automated data processing, pattern recognition, Neural network and expert system, case studies.

Text Books:

1. B. C. Majumdar. ***Introduction to Tribology of Bearings***. A. H. Wheeler & Co. Ltd**.**
2. A. Cameron and C. M. Mc Ettles. ***Basic Lubrication Theory***. Wiley Eartern Ltd., New Delhi**.**
3. S. Branned. ***Mechanical Signature Analysis: Theory and Application.*** Academic Publishers, London

Reference Books:

1. B. C. Nakra and K. K. Chaudhary. ***Instrumentation measurements and Analysis.*** Tata Mc Graw Hill Publishing company**.**

2. Sushil Kumar Srivastava. ***Maintenance Engineering and Management***. S. Chand & Company Ltd, New Delhi**.**
3. R. C. Mishra and K. Pathak. ***Maintenance Engineering and Management.*** Prentice Hall of India, New Delhi.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. identify the fault within system and causes of failure.
2. plan and analyse the route map for the maintenance.
3. learn basics of non-destructive testing methods.
4. analyse different methods of non-destructive testing.
5. diagnosis the techniques of minimizing the wear and analyse different methods.

ME 333 Plant Layout and Automated Material Handling

B. Tech (Mechanical Engg.) Sixth Semester
(Deptt. Elective – I)

L	T	P	C
3	0	0	3

Unit-1 Objectives of Facility Design: Types of layout problems, the layout function; organisation of layout: Product, process, Group Layout. Process design, product analysis, Computerised process planning

Unit-2 Analysis and design of Material flow: Systems approach to flow cycle, flow possibilities, facility layout, process charts, string diagram, flow process chart; quantitative analysis of material flow; line balancing techniques, optimal material flow configuration. Space and area allocation for production and physical plant service; Computerised handling of layout algorithms

Unit-3 Introduction to various Mechanical Handling Systems and equipment for handling unit load and bulk materials: pulley blocks, winches, electric hoists, EOT cranes, belt conveyor, Bucket elevator, Screw conveyor and pneumatic conveyor.

Unit-4 Kinematic analysis and design procedures of their component mechanisms. Design concept of warehouse facilities commensurate with adopted kind of handling and transfer devices; Concepts of AGVs, AS/RS and other automated materials handling devices. Automated packaging devices;

design of Integrated Plant Layout for Product Handling Systems.

Text Books:

1. S. C. Sharma. ***Plant layout and material handling***. Khanna publishers.
2. Agarwal. ***Plant layout and material handling.*** Jain brothers publication.
3. James M. Apple. ***Plant Layout and Material Handling.*** John Wiley & Sons.

Reference Books:

1. Richard L. Francis and John A. White. ***Facility Layout and Location – An Analytical Approach.*** Prentice Hall.
2. James M. Apple. ***Material Handling Systems Design.*** John Wiley & Sons.
3. Kroemer. ***Ergonomic Design of Material Handling Systems.*** KHE Lewis.
4. T.H. Allegri. ***Materials Handling (Principles & Practice).*** CBS

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand the procedures for systematic integration of organization.
2. learn various techniques and tools of layout planning.
3. get knowledge of various industrial layouts.
4. understand the material handling systems.
5. learn the concept of industrial building and industrial utilities.

ME 334 Ferrous and Nonferrous Material

B. Tech (Mechanical Engg.) Sixth Semester
(Deptt. Elective – I)

L	T	P	C
3	0	0	3

Unit-1 Ferrous Metals: Iron-Carbon equilibrium diagram; effects of alloy additions; types of steel – plain carbon steels, low alloy steels, heat treatable steels, tool steels, die steels, stainless steels, special steels; international systems to classify steel grades – AISI/SAE, DIN, EN series/BS, BIS; automotive grades and compositions; mechanical, thermal, electrical and physical properties of steels, applications.

Unit-2 Steel Making: Principles of steel making, melting practices, development of steel making processes, physiochemical principles and kinetic aspects of steel making, carbon boil, oxygen transport mechanism,

desulphurization, dephosphorization, slag-functions, composition control, properties and theories, raw materials for steel making and plant layout, effects of melting practices on end product, principle equipment used and applications of steel making processes.

Unit-3 Cast Iron: Types of Cast irons – grey cast irons, alloy CI, Spheroidal cast irons, white iron, malleable iron, vermicular cast irons; chemical compositions and properties.

Unit-4 Aluminium And Aluminium Base Alloys: enhancing properties of aluminium for auto applications; classification system and grades of alloys; roles of alloy additions on properties; significance of various equilibrium diagrams in designing alloys; solution treatment (age hardening) and microstructural changes; chemical compositions & properties of aluminium alloys; environmental benefits of recycling. aluminium alloy melting practices; component forming processes – castings, extrusions, sheet forming and forgings, material defects and their significances on properties and performances on end product; automotive applications of aluminium alloys and manufacturing processes for body to power train components.

Unit-5 Magnesium And Titanium Base Alloys: Properties and benefits over other traditional metals; classifications of alloys; melting practices; manufacturing processes – casting, extrusion and forging processes; solution treatment and microstructures; alloy compositions and properties; surface coatings; auto applications and limitations.

Text Books:

1. Flinn, R.A., and Trojan, P.K. ***Engineering Materials and their Applications.*** Jaico, 4th Edition.
2. ASM Metals Hand book. ***Failure Analysis and Prevention.*** 10th Edition, Vol.11, ASM.
3. Ashby M.F. ***Material Selection in Mechanical Design.*** Butter Worth 3rd Edition.

Reference Books:

1. Smithells ***Metals Reference Book***. 08th Edition.
2. ASM Metals Hand Book, ***Casting***. Vol.15, ASM International, 10th Edition.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. classify ferrous metals and alloys, and understand the effect of alloying elements in ferrous metals.
2. describe the different methods of processing of iron ores.
3. enumerate modern trends in iron making blast furnace.
4. determine kinetics of slag formation in furnaces.
5. describe processes for extraction of non-ferrous metals.
6. explain brief principles of alternative methods and their advantages and limitations.

ME 335	Fuel and Combustion	L T P C
	B. Tech (Mechanical Engg.) Sixth Semester	
	(Deptt. Elective – I)	**3 0 0 3**

Unit-1 Fuels: Detailed classification-Conventional and Unconventional Solid, History of Fuels, History of solid fuels, liquid fuels and gaseous fuels; Production, present scenario and consumption pattern of fuels, Definitions and properties of solid fuels, liquid and gaseous fuels.

Solid Fuels: Coal classification; composition and basis; Coal mining; Coal preparation and washing; Combustion of coal and coke making; Different types of coal combustion techniques; Coal tar distillation; Coal liquefaction; Coal gasification

Liquid Fuels: Exploration of crude petroleum; Evaluation of crude; Distillation; Atmospheric distillation; Vacuum distillation; Secondary processing; Cracking; Reformation of Naptha; Hydro treatment, dewaxing, deasphalting; Refinery equipment. Gaseous Fuels: Natural gas and LPG; Producer gas; Water gas; Hydrogen; Acetylene; Other fuel gases.

Unit-2 Thermodynamics of Combustion: Thermodynamic Properties, Laws of Thermodynamics, Stochiometry, Hess's Law, Enthalpy of formation, Heating value of fuel, Adiabatic flame Temperature; Fundamentals of Transport Phenomenon, Newton's Law of viscosity, Fourier's law of heat conduction, Fick's law of species diffusion, Conservation equations, Mass conservation equation, Momentum equations, Species transport equations, Energy Transport equations, Boundary layer concept, boundary layer solutions, Thermal boundary layer,

Turbulent boundary layer,

Unit-3 Chemistry of Combustion: Chemical composition, Flue gas analysis; Combustion stoichiometry. Chemical kinetics ,Rateofreaction, Reaction order, Zeroth, first, second and third order reactions, complex reactions, chain reactions, Combustion equilibrium dynamics; Theories of reaction Kinetics, General oxidation behaviour of hydrocarbon fuels. Conservation equation for multicomponent reacting systems.

Unit-4 Laminar And Turbulent Flames Propagation And Structure: One dimensional combustion wave, Laminar Premixed Flame, Burning velocity measurement methods, effects of physical and chemical variables on burning velocity, Flame extinction, Flammability limits, Flame Stabilization, Turbulent Premixed Flame. Gaseous Jet flames, Phenomenological analysis of Jet flame, Mechanism of soot formation; Combustion of liquid fuel: Droplet Fuel atomization; Droplet burning rate; Droplet combustion in convective environment; Types of injectors; spray formation and characteristics; Spray combustion model; Oil fired furnace combustion; gas turbine spray combustion; direct injection engine combustion; Combustion of solid fuels: Diffusional theory for single coal particle combustion; Combustion of Carbon sphere with CO burning gas phase.

Unit-5 Environmental Considerations: Chemicals from combustion, emission of CO, CO_2, water vapor, Oxides of Nitrogen, Hydrocarbon, Oxides of Sulphur and Soot particles. Quantification of emissions, emission reduction methods.

Text Books:

1. Wilfrid Francis, Martin C. Peters and Pergamon. ***Fuels and Fuel Technology: A Summarized Manual***, 2nd Edition .
2. Stephen R.Turns . ***An Introduction to Combustion.*** McGraw Hill International Edition.
3. Roger Astrehlow. ***Combustion Fundamentals***. McGrawHill.

Reference Books:

1. ShahaA.K. ***Combustion Engineering and Fuel Technology.*** Oxford and IBH.
2. KannethK.Kuo. ***Principles of Combustion.*** Wiley and Sons.
3. Gary L. Berman and Kenneth W. Ragland. ***Combustion Engineering.*** McGraw Hill International Edition.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. learn the basics, theory and physical concepts of combustion.
2. recognize the different types fuels used in combustion.
3. understand the different configurations of flames and boundary layer combustion.
4. learn combustion stoichiometry and chemical equilibrium.
5. understand the advanced treatment of fundamental combustion processes.

ME 336	Theory of Elasticity and Plasticity **B. Tech (Mechanical Engg.) Sixth Semester** **(Deptt. Elective – I)**	**L T P C** **3 0 0 3**

Unit-1 Theory of Elasticity: Concept of stress, stress tensors, equilibrium equations, octahedral stresses, concept of strain, strain tensors, generalized Hooke's law, elastic strain energy. Constitutive relations, equilibrium equations, compatibility equations and boundary conditions in 2-D and 3-D cases. Transformation of stress and strain at a point, Principal stresses and principal strains, invariants of stress and strain.

Unit-2 Plane stress and plane strain: Airy's stress function approach to 2-D problems of elasticity, simple problems. Solution of axi-symmetric problems, stress concentration due to the presence of circular hole in plates. Elementary problems of elasticity in 3-D, stretching of a prismatic bar by its own weight, torsion of circular and non-circular shafts, membrane analogy.

Unit-3 Bending: Analysis for stresses under bending, Non-linear stress strain curve, shear stress distribution, residual stresses in plastic bending.

Torsion: Introduction, plastic torsion of a circular bar, elastic perfectly plastic material, elastic work hardening of material, residual stresses and problems.

Unit-4 Theory of Plasticity: Introduction to ideally plastic solids: Ideally plastic solid, stress space and strain space, General nature of the yield locus, Yield surfaces of Tresca and Von Mises, plastic work, effective stress, effective strain, stress-strain relations (plastic flow), principle of normality, Prandtl-Reuss equations, Saint Venant – Von Mises equations, incremental and deformation theories, convexity of yield surface. Theory of instability

during plastic deformation.

Unit-5 Slip line field theory: Introduction, stresses in conditions of plain strain, convention for slip lines, solutions of plastic deformation problem, Geometry of slip line field, Properties of the slip lines, construction of slip line fields and hodographs.

Unit-6 Elastic-Perfect Plasticity: Introduction, elastic-plastic bending of beams, elastic-plastic torsion, thick walled, pressurized cylinder, thin disc under pressure and rotating disc.

Text Books:

1. Timoshenko and Goodier. ***Theory of Elasticity***. McGraw Hill **.**
2. Srinath L. S. ***Advanced Mechanics of Solids.*** Tata McGraw Hill **.**
3. Popov EP. ***Introduction of Mechanics of Solids.*** PHI Pvt. Ltd, New Delhi.

Reference Books:

1. Chakraborty J. ***Theory of Plasticity.*** Elsevier.
2. Narayanasamy and Ponalagusamy. ***Theory of Engineering Plasticity.*** Ahuja Book Co. Pvt. Ltd.
3. Rees D.W.A. ***Basic Engineering Plasticity.*** Elsevier.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand the fundamentals of elasticity and plasticity.
2. analyze the elastic body subjected to plane stress and plane strain.
3. analyze the bending and torsion problems.
4. apply theories of elasticity and plasticity for solving the real-life engineering problems.

ME 337 Gas Dynamics L T P C

B. Tech (Mechanical Engg.) Sixth Semester
(Deptt. Elective – I)

3 0 0 3

Unit-1 Fundamentals of compressible flow: Ideal gas relationship, The adiabatic energy equation, Mach number and its significance, Mach waves, Mach cone and Mach angle, static and stagnation states, relationship between

stagnation temperature, pressure, density and enthalpy in terms of Mach number, stagnation velocity of sound, reference speeds, various regions of flow, Effect of Mach number on compressibility, Area velocity relationship.

Unit-2 One Dimensional Isentropic flow: General features of isentropic flow, performance curve, Comparison of adiabatic and isentropic process, One dimensional isentropic flow in ducts of varying cross-section- nozzles and diffusers, operation of nozzles under varying pressure ratio, mass flow rate in nozzles, critical properties and choking, area ratio as function of Mach number, Impulse function, non-dimensional mass flow rate in terms of pressure ratio, area ratio and Mach number, Working charts and gas tables, Application of Isentropic flow.

Unit-3 Normal shock: Development of shock wave, governing equations, Prandtl-Mayer relation, Rankine-Hugoniot relation, strength of shock wave, Mach number in the downstream of normal shock, variation of flow parameters across the normal shock, normal shock in Fanno and Rayleigh flows, impossibility of a rarefaction shock, supersonic diffusers, oblique shocks and their analysis.

Unit-4 Flow in constant area duct with friction (Fanno flow): Fanno curve and Fanno flow equations, solution of Fanno flow equations, variation of flow properties, variation of Mach no. with duct length, isothermal flow in constant area duct with friction, tables and charts for Fanno flow, Experimental friction coefficients.

Unit-5 Flow in constant area duct with heat transfer (Rayleigh flow): Rayleigh curve and Rayleigh flow equations, variations of flow properties, maximum heat transfer, tables and charts for Rayleigh flow.

Unit-6 Wind tunnel: Types of wind tunnels – sub sonic tunnel, supersonic wind tunnel, projectile obstruction and shadow graph technique. Project based learning in gas dynamics.

Text Books:

1. Ascher H. Shapiro. ***The dynamics and thermodynamics of Compressible fluid low.*** Volume-I, the Ronald Press Company, New York.
2. John D. Anderson. ***Modern Compressible Flow: With Historical Perspective.***

McGraw-Hill Higher Education.
3. E. Rathakrishnan. ***Gas Dynamics***. PHI Learning Pvt. Ltd

Reference Books:

1. P. Balachandran. ***Fundamentals of compressible fluid dynamics.*** PHI Learning, New Delhi.
2. Liepmann H.W. and Roshko,A. ***Elements of Gas Dynamics***. Dover Publications, Inc., Mineola, NY, USA.
3. Oosthuizen P.H., and Carscallen W.E. ***Compressible Fluid Flow***. McGraw-Hill International editions, McGraw-Hill Companies, Inc., Singapore.
4. Chapman A.J. and Walker W.F. ***Introductory Gas Dynamics Holt, Reinhart and Winston.*** Inc. NY, USA.
5. Thompson, P.A. ***Compressible Fluid dynamics.*** Mc Graw Hill.
6. P. Murugaperumal. ***Gas Dynamics and Jet Propulsion.*** Scitech Publication, Chennai.
7. S. M. Yahya. ***Fundamental of Compressible flow***. New age international Publication, Delhi.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand fundamental principles of gas dynamics.
2. learn the flow physics of gas dynamics.
3. understand the normal shocks and oblique shocks.
4. design the wind tunnel.
5. perform good project in the area of gas dynamics on the principles of gas dynamics.

ME 338 Gas Turbine and Jet Propulsion L T P C

B. Tech (Mechanical Engg.) Sixth Semester
(Deptt. Elective – I)

3 0 0 3

Unit-1 Introduction to jet propulsion**:** The Gas Turbine Engine development for jet Propulsion; Jet engine performance parameters: Thrust, SFC, Efficiencies; Simple Turbojet and Reheat engines: Low and High bypass Turbofan engines; Single and Multi-spool Gas Turbine based propulsive devices.

Unit-2 Real Cycle Thermodynamic Analysis**:** Ideal and Real Brayton cycles; Jet engine cycles for aircraft propulsion; Cycle components and component

performance: Intake, Compressors & Turbines, Combustion chamber, Afterburner, Nozzle; Analysis of engine real cycles: Turbojet cycle, Reheat engine cycle, Turbofan engine cycle, Turboprop Engines; Advanced jet engine cycles: Variable cycle engines.

Unit-3 Fundamentals of Rotating Components**:** Thermodynamics of Compressors and Turbines; Development of parameters for compressor and Turbines.

Compressors and Turbines**:** Axial and centrifugal Compressors: A simple two dimensional analytical model; 2-D (cascade) analysis; Loss and Blade performance estimation; Simple Free Vortex theory; Single and Multi-stage Axial compressor characteristics; Elements of centrifugal compressor; Inlet Duct; Impeller; Slip factor and Concept of Rotor enthalpy; Centrifugal Compressor Characteristics: Surging and Choking.

Axial and Radial flow turbines**:** Introduction; Turbine stage : Turbine Blade 2-D (cascade) analysis; Work Done, Degree of Reaction, Losses and Efficiency; Multi-staging of Turbine; Turbine Cooling Technology; Radial Turbine Aerodynamics and Thermodynamics; Losses in radial turbine and efficiency.

Unit-4 Combustion Systems: Introduction: Various types of combustion chambers in aircraft engines; Combustion Mechanism and Important Combustion parameters; Development of a practical combustion system and design parameters; Pressure losses ; Combustion efficiency; Combustion intensity; Combustion Stability limits and Instability; Fuels and their properties and Fuel injection systems.

Unit-5 Intakes and Propelling Nozzles: Intakes**:** Requirements of an Intake for Power plant: Transport, Military Aircraft; Subsonic Intakes, Transonic and Supersonic Intakes; Axi-symmetric and Asymmetric Intakes; Aircraft Intake design considerations.

PropellingNozzles**:** Energy conversion in a Nozzle; Nozzle design considerations: fixed and variable geometry nozzles; C-D nozzle and their use.

Unit-6 Engine Installed Performance, Sizing & Matching**:** Introduction to engine component sizing; Installed Performance of Engine; Dimensional analysis for component matching; Engine - Design Point Operations; Engine Off

Design Operations; Single Shaft Engine; Two-Shaft : Turbojet & Turboprop, Turbo-shaft Engines; The Engine Operating Lines; Operational details of multiple shaft engines; Aircraft Engine component matching: Intake-Compressor matching; Turbine-Nozzle matching; Compressor - Turbine matching : Single and Multi-spool; Free Turbine and Unducted Fan / Propeller matching.

Unit-7 Ramjets, Pulsejets and Scramjets**:** Use of Ramjets and Pulsejets in Aircraft propulsion; Operating Principles; Thermodynamic Cycle; Performance Parameters; Design and Performance of a Ramjet; Flow in Diffusers; Combustors and Nozzles; Principles of Scramjet Engines. Future of jet Propulsion in near future

Text Books:

1. Hill and Peterson. ***Mechanics and Thermodynamics of Propulsion.*** 2nd Edition, Addison-Wesley**.**
2. HIH Saravanamutto, H. Cohen and GFC Rogers. ***Gas Turbine Theory***. Pearson Education Canada**.**
3. V. Ganesan. ***Gas Turbine***. **McGraw Hill Education**

Reference Books:

1. J. D. Mattingly. ***Elements of Gas Turbine Propulsion.*** McGraw-Hill **.**
2. Sutton, G.S. Rocket. ***Propulsion Elements.*** Sixth Edition, Wiley Interscience.
3. Roy Bhaskar. ***Aircraft Propulsion.*** Elsevier (India).
4. El-Sayed Ahmed. ***Aircraft Propulsion and gas Turbine Engines***. Taylor and Francis (CRC press).

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. explain the basic fundamental of the various gas turbine cycles.
2. discuss the various laws pertaining to gas turbines and jet propulsion.
3. identify, formulate and solve problems related to gas turbines and jet propulsion.
4. design a gas turbine engine using the understanding of the relationship between components, at least at the level of selecting the number of spools and stages.

ME 339	Metal Cutting and Cutting Tool Design B. Tech (Mechanical Engg.) Sixth Semester (Deptt. Elective – I)	L T P C 3 0 0 3

Unit-1 Metal cutting operations and terminology: Introduction to machining operations e.g. turning, boring, drilling, facing, forming and parting off ,milling, shaping, and planning, broaching.

Unit-2 The essential features of metal cutting: occurrences of various phenomena during machining. Chip formation mechanism, Transitional flow region concept, Secondary deformation region, Material flow stress in PDZ, Effect of various parameters on machining, Chip reduction co- efficient, Shear angle, Micro-hardness variation in chip, Plastic strain variation in chip, Chip curling. Various natures of chips, Chip breakability, Parameter selection for better chip breakability.

Unit-3 Forces of metal cutting: Mechanics of metal cutting, Merchant' theory.
Cutting tool materials: Design of tool material e.g. Carbon steel tools, H.S.S. etc.
Tool life: Various types of tool wear, Taylor's tool life equation, Ways to determine tool life during machining. Effect of material properties on tool life, Effect of tool geometry on tool life, Machining parameter selection for tool life improvement.

Unit-4 Machinability: Machinability assessment. Effect of parameters on machinability, Effect of heat treatment on machinability, Machinability improvement.

Unit-5 Design of single point cutting tools: Design of tool shank, design of tool tips. Tool design for chip breakability improvement.
Optimization of tool shape: Effect of various tool shape.

Text Books:

1. E.M. Trent. ***Theory of metal cutting***. Butterworths publishers , London
2. G. Boothroyd. ***Fundamentals of metal machining and machine tools***. Mc Graw Hill publishers

Reference Books:

1. Bhattacharyya. ***Metal cutting theory and practice***. Central book publishers, Kolkata.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. develop the relations for chip reduction coefficient, shear angle, shear strain, forces, power, specific energy and temperatures associated with orthogonal cutting.
2. develop shear angle relationships for natural and controlled contact cutting and stress-strain relations in orthogonal cutting.
3. explain the tool geometry and understand the physical metallurgy during selection of tool material
4. select cutting fluids, cutting tool materials and tool geometry for improving machinability and tool life.

ME 381	Computational Fluid Dynamics	L T P C
	B. Tech (Mechanical Engg.) Sixth Semester	
	(Open Elective – I)	**3 0 0 3**

Unit-1 Introduction -Theoretical, Computational and Experimental Techniques and their comparison. Scope of CFD. Different CFD Approaches. Modeling, Discretization and Basic Solution Module. Convergence, Stability and Consistency.

Unit-2 Modeling in CFD - Navier-Stokes Equation for Laminar Flow in Cartesian Coordinate System. Potential, Boundary-Layer and Fully Viscous Modeling Stream function-Vorticity Formulation. Boundary Conditions in Different Formulations and Case Studies like Potential and Viscous Modeling of Flow in a Cavity, Boundary- Layer Modeling of Flow over a Flat Plate and Viscous Modeling of Flow in Entrance-Region for Flow between Parallel Plates. Overview of Navier-Stokes and Scalar Transport Equations.

Unit-3 Introduction to Finite Difference, Taylor Series, Expansion, Evaluation of First and Second Order Derivatives, Truncation Error, Numerical Solution of One Dimensional Problems, One Dimensional Transient Heat Conduction Equation, Finite Volume and Integral Method of Discretisation, Solution by Tri-Diagonal-Matrix Algorithm. Consistency and Stability of Numerical Methods, Fourier Stability Analysis. Direction Implicitly (ADI) method, Solution of Poisson Equation, Solution of Linear System of Equations, Formulation for Steady One-Dimensional Convection-Diffusion Problems, Central Upwind, Exact Hybrid and Power Law Schemes, Deferred

correction method.

Unit-4 Discretisation of convection-diffusion equations in two and three dimensions, solution of Navier Stokes and scalar transport equations in primitive variables, SIMPLE, SIMPLER and SIMPLEC algorithm on staggered grid, Different boundary conditions, wall, symmetry, exit periodic boundary conditions, convective and radiative boundary conditions

Text Books:

1. H K Versteeg and W Malalasekera. ***An introduction to computational fluid dynamics***.
2. S. V. Patankar. ***Numerical Heat Transfer and Fluid Flow***.
3. J. D. Anderson. ***Computational Fluid Dynamics***.

Reference Books:

1. Lewis, Nithiarasu and Seetharamu. ***Fundamentals of the finite element method for heat and fluid flow.***
2. J.N.Reddy.***Introduction to the finite element method.***
3. Bathe. ***Finite element procedures in engineering analysis.***
4. M. Peric. ***Computational Methods for fluid Dynamics.***

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand both flow physics and mathematical properties of governing Navier-Stokes equations and define proper boundary conditions for solution describe various flow features in terms of appropriate fluid mechanical principles and force balances.
2. use finite difference and finite volume methods in CFD modelling.
3. use CFD software to model relevant engineering flow problems and analyse the CFD results.

ME 382 Finite Element Method L T P C

B. Tech (Mechanical Engg.) Sixth Semester
(Open Elective – I)

3 0 0 3

Unit-1 Review of theory of elasticity and Mathematical models for structural problems; Historical Perspective of FEM and applicability to mechanical

engineering systems.

Unit-2 Introduction to Variational methods and Overview on approximate methods and weighted residual methods. Philosophy of solving continuum problems using Finite Element method and Generalized FE formulation for 1-D element through minimization of potential, displacement-based formulation; Compatibility conditions, Assembly of stiffness matrix and Properties of stiffness matrix. Boundary considerations, Elimination method, Penalty Method, Convergence criterion and Mesh refinement. Formulation of Finite element characteristic equations for plane Truss elements.

Unit-3 Evaluation of stresses and support reaction in plane truss system. Analyzing plane truss using Reflective symmetry techniques. Review of bending of beams, higher order continuity (C0 and C1 Continuity); Formulation of Finite element characteristic matrices for beam element. Introduction to Plane stress and Plain strain condition and development of Finite element characteristic Equation and Stiffness Matrix for constant-strain triangle (CST) element.

Unit-4 Determination of von Mises stresses in the element. Derivation of the Stiffness Matrix Axisymmetric Elements. Appling Axisymmetric Elements formulation pressure vessel. Formulation of Finite element characteristic equations using 1 D element for heat-transfer, fluid flow problems and vibration analysis.

Text Books:

1. Daryl L. Logan. ***A First Course in the Finite Element Method.*** Fourth Edition Thomson Canada Limited.
2. David Hutton. ***Fundamentals of Finite Element Analysis***. Tata McGraw Hill.
3. Reddy J.N. ***Finite Element Method in Engineering.*** Tata McGraw Hill.

Reference Books:

1. Singiresu S. Rao. ***Finite element Method in Engineering***. Elsevier
2. Zeincowicz. ***The Finite Element Method for Solid and Structural Mechanics***. 4th Edition, Elsevier.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. formulate characteristic equations and solve problems in 1-D structures including trusses, beams and frames.
2. formulate basic equations for two dimensional elements and analyze plain stress, plain strain conditions.
3. solve problems using 1-D, 2-D and 3-D elements in solid mechanics, fluid mechanics and heat transfer field.
4. develop algorithm to solve the finite element formulations.

ME 383	Reliability Engineering	L T P C
	B. Tech (Mechanical Engg.) Sixth Semester	
	(Open Elective – I)	**3 0 0 3**

Unit-1 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.

Unit-2 Introduction to reliability function: Structure functions, reliability of systems of independent components, bounds on the reliability function, the inclusion exclusion method, the intersection method.

Unit-3 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.

Unit-4 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.

Unit-5 Reliability in design: defining the user requirement, setting reliability metrics and definitions, risk assessment, objective based framework for product development.

Unit-6 Aspects of reliability: 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.

Text Books:

1. Balaguruswamy E. ***Reliability Engineering***. TMH .
2. Ebeling. ***An Introduction to Reliability and Maintainability Engineering.*** McGraw-Hill, 1/e.
3. Birolini A. ***Reliability Engineering - Theory and Practice.*** Springer

Reference Books:

1. Patrick D. T. O'Connor. ***Practical Reliability Engineering.*** 4th Ed.Wiley.
2. Aggarwal K.K. ***Reliability Engineering.*** SPRINGER (SIE).
3. Guang Yang. ***Life Cycle Reliability Engineering***. 1st Edition, Wiley.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand and comprehend the fundamentals of reliability analysis of engineering components and systems.
2. explain and describe the modus operandi for replacement or repair, maintenance, inspection and quality control.
3. identify and investigate the system depicting the probable causes of failure and needs for maintenance.
4. design and analyze the component or system based on reliability analysis.

ME 384	**Renewable Energy**	**L T P C**
	B. Tech (Mechanical Engg.) Sixth Semester	**3 0 0 3**
	(Open Elective – I)	

Unit-1 Introduction: Various non-conventional energy resources, potential of renewable energy sources global as well as Indian scenario.

Unit-2 Solar energy: Solar radiation, measurement of solar radiation, solar collector-flat plate and concentrating, collector efficiency, storage of solar energy, application of solar energy. Solar PVS

Unit-3 Wind energy: Principles of wind energy conversion, various types of wind

machines.

Energy from bio-mass: Bio-mass conversion technologies, Solid biofuel sources, Gasification of solid biofuels, MSW incineration plants, Bio alcohols, different production processes, Biodiesels, biodiesel production processes, Different types of bio gas plants,.

Unit-4 Geothermal energy: Geothermal resources, Different types of geothermal plants, advantages and disadvantages over other nonconventional energy resources.

Energy from the ocean: Ocean energy conversion technologies, wave energy, Ocean thermal energy conversion, open and closed cycle, hybrid cycle, introduction to tidal energy.

Hydrogen energy: Production processes, storage of hydrogen energy, application.

Unit-5 Hybrid renewable energy:- Necessity of hybrid systems, utility-scale hybrid energy systems, Geothermal + solar PV systems, Biomass + solar CSP systems, Solar PV + fuel cells systems, Wind + solar PV systems, Biodiesel + wind power systems, Gas + solar CSP systems, Coal + solar CSP systems, Energy Storage Systems, Pumped hydropower storage, Compressed air energy storage (CAES) , Adiabatic compressed air energy storage for electricity (ADELE), Molten salt energy storage (MSES), Batteries , Flywheels.

Text Books:

1. B.H Khan. ***Non-Conventional Energy Resources***. McGraw-Hill, 2e**.**
2. Sukhatme. ***Solar Energy: Principles of Thermal Collection and Storage***. McGarw-Hill.

Reference Books:

1. Grag. ***Solar Energy: Fundamentals and Applications***. McGraw-Hill, 1st Revised Edition)**.**
2. L.A. Kristoferson and V. Bokalders. ***Renewable Energy Technologies: Their Applications in Developing Countries***. ITDG Publishing.
3. S Hasan Saeed and D.K. Sharma***. Non-conventional Energy Resources***. S.K. Kataria & Sons.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. define basic properties of different renewable sources of energy and technologies for their utilisation.
2. learn the present energy scenario and the need for energy conservation.
3. understand the various forms of non-conventional energy resources.
4. outline division aspects and utilization of renewable energy sources for both domestics and industrial application.
5. undertake simple analysis of energy potential of renewable sources of energy.

ME 385 Engineering Inspection and Quality Control

L T P C

3 0 0 3

B. Tech (Mechanical Engg.) Sixth Semester

(Open Elective – I)

Unit-1 Interchangeability e.g. Interchangeable system of manufacture, Types of interchangeability, Limit gauges, Taylor's principle of gauging, design of inspection gauges.

Unit-2 Surface texture: Numerical assessment of surface texture, use of stylus type instruments. Gear Measurement of gear elements, gear errors. Thread Measurement of thread elements, thread errors. Comparators Mechanical, optical, optomechanical, pneumatic comparators.

Unit-3 Optical instruments Optical principles of measurements, Tool maker's microscope. Interferometer Principles of measurement by method of interferometry, NPL gauge interferometer. Statistical quality control Causes of variation in quality characteristics, principle of quality control by the use of control charts.

Text Books:

1. M. Mahajan. ***A text book of metrology***, Dhanpat Rai and Co; .
2. Siegmund Halpern. ***The assurance sciences***, Prentice Hall of India Pvt Ltd.

Reference Books:

1. Grant, E. L. and Leavenworth, R.S., ***Statistical Quality Control***, McGraw Hill International, New York (2008).
2. Besterfield, D.H., ***Total Quality Management***, Pearson Education Asia, New Delhi (2003).

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand the working of various types of contact and non-contact type of measuring instruments.
2. identify and analyze the functions and organization of industrial inspection.
3. apply and analyze the ishikawa's tools and conduct quality cost analysis.
4. analyze various control charts for quality control of the different production processes.
5. apply the basic concepts involved in the working of instruments for surface texture, line and angle measurements.

ME 401 Industrial Engineering and Operations Research L T P C

B. Tech (Mechanical Engg.) Seventh Semester (Core) 3 0 0 3

Unit-1 Quality: Introduction and definitions of quality, Evolution of Quality: Inspection, Quality Control, Customer-Orientation: Internal & External Customer Concept, Life cycle approach to quality costs- Prevention; Appraisal and Failure costs. Seven QC tools (Histogram, Check sheets, Ishikawa diagrams, Pareto, Scatter diagrams, Control charts). Process capability concepts.

Unit-2 Reliability: Introduction, Definitions, reliability evaluation, maintainability, and availability concepts.

Facilities Design: Site Selection, Factors influencing the selection, rural and urban locations of sites, optimum decision on choice of site and analysis.

Unit-3 Plant Layout: Types of production, types of layouts, advantages and disadvantages of layout, factor affecting layout, systematic layout planning.

Unit-4 Operations Research: Linear programming, simplex method, transportation, assignment, network flow models, simple queuing models, Project scheduling with CPM, Project scheduling with PERT, crashing of network.

Unit-5 Capacity Planning: Introduction, measures of capacity, capacity strategies, A systematic approach for capacity decisions, Long range capacity planning and control, Medium range capacity planning and control, Short range capacity planning and control.

Unit-6 Inventory Management: Introduction, Inventory related costs, EOQ model, EPO model, Inventory models allowing shortages, Inventory models allowing price discounts, Inventory model under risk conditions, Inventory control systems: continuous review, periodic review, optional replenishment etc., Inventory classification systems: ABC, FMS, VED etc, MRP.

Unit-7 Forecasting: Introduction, Demand patterns, Factors affecting demand, Subjective forecasting methods, Casual forecasting methods, Time series forecasting methods, Routine short term forecasting methods, Selection of forecasting model.

Unit-8 Production Planning and Control: Introduction, System approach, Type of

manufacturing systems, Factors affecting manufacturing systems. Break even analysis, economics of a new design, production aspects, Aggregate production planning, materials requirement planning.

Text Books:

1. S.N. Chary. ***Production And Operations Management.*** McGraw Hill Publ, 5th Edition.
2. Chase. ***Operations and Supply Management (SIE).*** McGraw Hill Publ, 12/e.

Reference Books:

1. Saxena. ***Production and Operations Management***. McGraw Hill Publ, 2/e.
2. O.P. Khanna. ***Industrial engineering and management***. Dhanpat Rai & Sons.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand the mathematical tools that are needed to formulate & solve transportation problems for optimization,
2. design, implement, and analyze computational experiments.
3. recognize the importance and value of operations research and mathematical modeling in solving practical problems in industry by linear programming problems
4. formulate and analyze a managerial decision problem into a mathematical model using investment analysis such as use of mathematical models to solve the inventory and replacement problems; use of network models and techniques for effective decisions–making.
5. apply the knowledge and tools of operation research in various industries like marketing, material handling etc.

ME 431 Advanced Machining Process L T P C

B. Tech (Mechanical Engg.) Seventh Semester
(Deptt. Elective–II)

3 1 0 4

Unit-1 Introduction: Introduction, characteristics, and need of advanced machining processes, classification.

Unit-2 Mechanical Processes: Abrasive Jet Machining (AJM) –Principle, equipment, process parameters, applications, advantages and limitations.
Ultrasonic Machining (USM) – Working principle, equipment, transducers,

concentrator, feed mechanism, acoustic head clamping, process parameters, applications advantages and limitations.

Unit-3 Water Jet Machining (WJM) – Principle, equipment, process parameters, applications, advantages and limitations.

Abrasive flow machining (AFM) - Working principle, equipment, process capabilities and applications, advantages and limitations.

Unit-4 Chemical Processes: Chemical Machining (CHM) –Principle, controlling parameters, masking techniques, Photochemical Machining (PCM) applications, advantages and limitations.

Electrochemical Machining (ECM) – Operating principle, equipment, power supply and control, tool design, process parameters, applications, advantages and limitations.

Electrothermal Processes: Basic concept of Electrothermal Processes and mechanism of material removal.

Unit-5 Electrical Discharge Machining (EDM) – Operating principle, electrode materials, dielectric fluid, gap flushing, equipment, different EDM operations, power generator, Wire EDM, process parameters and their effects, applications, advantages and limitations.

Laser Beam Machining (LBM) – Laser fundamentals, lasing materials, types of industrial lasers, material processing with lasers, applications of laser machining, advantages and limitations.

Unit-6 Electron Beam Machining (EBM) – Process principle, equipment, process parameters, applications advantages and limitations.

Plasma Arc Machining (PAM) –Principle of plasma arc, plasma arc torches, process parameters, applications, advantages and disadvantages.

Ion Beam Machining (IBM) –Principle of material removal, beam source, IBM setup, process parameters, applications, advantages and limitations.

Text Books:

1. G. F. Benedict. ***Nontraditional Manufacturing Processes***. Marcel Dekker Inc
2. V. K. Jain. ***Advanced Machining Processes***. Allied Publishing Pvt. Ltd.
3. P. K. Mishra. ***Nonconventional Machining***. Narosa Publishing House

Reference Books:

1. A. Ghosh and A. K. Mallik. ***Manufacturing Science***. Affiliated East-West Press Pvt. Ltd.
2. Pandey. ***Modern Machining Process***. McGraw-Hill.
3. G. Boothroyd and W.A. Knight. ***Fundamentals of Machining and Machine Tools.*** CRC Press, Taylor & Francis Group.
4. J. A. McGeogh. ***Advanced Methods of Machining***: Chapman & Hall

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. categorize the various advanced manufacturing process based on energy sources and mechanism employed.
2. select the best suitable advanced manufacturing process for processing of advanced materials employed in modern manufacturing industries.
3. evaluate the role of each process parameter during machining of various advanced materials.
4. Understand the requirements to achieve maximum material removal rate and best quality of machined surface while machining various industrial engineering materials.

ME 432 Convective Heat and Mass Transfer

L T P C

3 1 0 4

B. Tech (Mechanical Engg.) Seventh Semester
(Deptt. Elective–II)

Unit-1 Introduction; Basic Equations: Reynolds Transport Theorem; Compressible and Incompressible Flows. Derivation of Energy Equation using specific coordinate system; Preliminaries on the Tensor Analysis; Derivation of Energy Equation (using Generalized Approach). Important Dimensionless Numbers; Concepts of velocity boundary layer and thermal boundary layer, displacement thickness, momentum thickness and energy thickness. Derivation of velocity boundary layer and thermal boundary layer equations.

Unit-2 External Flows: Flow over a Flat Plate; Blasius Solution, Temperature distribution over a flat plate boundary layer (derivation of the ordinary differential equations from the partial differential equations)

Numerical Solution (shooting technique); Analytical Solution (Series Solution, principles of similarity and the similarity solution of velocity

boundary layer. Approximate Method (Karman-Pohlhausen Method) for flow over a heated flat plate. Solution of Momentum Integral equations (including the cases of suction and blowing). Solution of Energy Integral equation for the case of Pr>1. Effect of pressure gradient on heat transfer in Integral solutions.

Unit-3 Viscous dissipation effects on Boundary Layer Flow over a Heated Flat Plate. Influence of Prandtl number and Eckert number. Solution of Falkner-Skan Equation for flow and heat transfer over non-zero pressure gradient surface. Analysis of Heat Transfer and Flow over a Circular Cylinder.

Unit-4 Internal Flows: Fully developed flows through pipes and ducts (analytical solution). Thermal considerations; Physical significance of Prandtl number. Flow of low Prandtl number fluids. Thermally fully developed conditions (for uniform wall heat flux and uniform wall temperature cases); Heat transfer through a circular tube for hydrodynamically developed and thermally developed flow with uniform wall heat flux boundary condition

Heat transfer through a circular tube for hydrodynamically developed and thermally developed flow with uniform wall temperature boundary condition.

Unit-5 Graetz Problem: Heat transfer through a circular tube for hydrodynamically developed and thermally developing flow with uniform wall heat flux boundary condition. Numerical Solution of Navier-Stokes and Energy Equations for 3-D Incompressible Flows through a rectangular duct (to be continued)

Unit-6 Turbulent Flow and Heat Transfer: Classical Idealization of Turbulent Flows, Concept Eddy Viscosity and Eddy Diffusivity Turbulent Boundary Layer; Universal velocity Profile; Laws of Wall Turbulent Flow and Heat transfer through a pipe; Chilton-Colburn Analogy, Reynolds Analogy; Convection Correlations, Computational Approaches for solving turbulent flows and k-epsilon model of turbulence.

Unit-7 Free Convection: Analytical solution for flow over a heated vertical plate.

Free Convective Flows for other important geometries; Mixed Convection; Influence of Richardson number, Archimedes number. Condensation; Transpiration cooling.

Unit-8 Boiling; Nucleation and Bubble Growth; Homogeneous Nucleation; Heterogeneous Nucleation; Bubble Growth Without Heat and Mass Transfer; Convective Mass Transfer; The Concentration boundary layer; Heat and Mass Transfer Analogy; Numerical Solution of Simplified flows involving convective heat transfer

Text Book:

1. P.S. Ghoshdastidar. ***Heat Transfer***. Oxford publications.
2. Adrian Bejan. ***Convection Heat Transfer***. Wiley India Pvt. Ltd.

Reference Books:

1. W. M. Kays and E. M. Crawford. Convective ***Heat & Mass Transfer***. McGraw-Hill.
2. Louis C Burmeister. ***Convective Heat Transfer.***

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. familiar with laminar boundary layer and turbulent flow.
2. understand the basic equations governing the phenomena in convective heat transfer.
3. get experience, confidence, and good critical judgment in the application of numerical methods to the solution of physical problems.
4. apply the knowledge in designing the experiments for thermal systems.

ME 433 Fundamentals of Industrial Design

B. Tech (Mechanical Engg.) Seventh Semester
(Deptt. Elective–II)

L	T	P	C
3	1	0	4

Unit-1 Introduction: The design process, Steps in design process, Morphology of design, Mechanical engineering design, Traditional design methods, Design synthesis, Aesthetic and ergonomic considerations in design, Use of standards in design, Selection of preferred sizes, design for Maintenance (DFM).

Unit-2 Sources of Information and Communicating the Design: The information problem, Copyright and copying, Sources of information, Patents, Elements of communication system, Recording of results, Writing the technical

report, Conducting a meeting, Oral presentation, Visual aids and graphics.

Unit-3 Materials Selection: Performance characteristics of materials, Materials selection process, Economics of materials, Evaluation methods of materials selection – cost versus performance relation, weighted index, value analysis.

Unit-4 Manufacturing Considerations in Design: Role of processing in design, Types of manufacturing processes, Economics of manufacturing, Design for castings, Forgings, Sheet metal forming, Design for machining, Powder metallurgy, Welding, Heat treatment, Assembly, Corrosion resistance, Designing with plastics, Concurrent engineering approach

Unit-5 Value Engineering: Introduction, Categories of costs, Methods of developing cost estimates, Cost indexes, Cost-capacity factors, Factor methods of cost estimation, Manufacturing costs, Overhead costs, Standard costs, How to price product, Life cycle cost

Unit-6 Economic Design Making: Mathematics of time value of money, Cost comparison, Depreciation, Taxes, Profitability of investments, Inflation, Sensitivity and break-even analysis, Uncertainty in economic analysis, Benefit cost analysis

Text Books:

1. George Ellwood Dieter. ***Engineering Design: A Materials and Processing Approach.*** McGraw-Hill; 4th edition.

Reference Books:

1. V. B. Bhandari. ***Design of Machine Elements.*** TMH, 3/e.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand the concepts and applications of design along with process, morphology and synthesis in conjunction to industrial design methods.
2. gain a basic understanding of the important aspects of design communications e.g., preparing technical presentation, report, thesis.
3. apply the various aspects of material selection process for cost-effective value-added design.

4. apply the practical aspects of manufacturing considerations in design and subsequent recommendations.
5. design and analyze the different types of costs and estimation in design for economic decision making.

ME 434 **Viscous Fluid Flow** **L T P C**

B. Tech (Mechanical Engg.) Seventh Semester

(Deptt. Elective–II) **3 1 0 4**

Unit-1 General equations of motion for a viscous fluid, stress tensor, constitutive law for a viscous fluid, derivation of the Navier Stokes Equations. Reynolds number, boundary conditions for fluid flow, Incompressible flow, exact solutions of the equations of motion.

Unit-2 General Principles of viscous flows. Reynolds number, dynamical similarity and vorticity, Lubrication theory, Low Reynolds number flows, high Reynolds number flows (fast, big and smooth), Boundary layer theory, Boundary layer stability, Boundary layers, laminar, boundary layer properties and characteristics.

Unit-3 Blasius solution, Falkner-Skan solutions, boundary layer separation, Karman momentum integral equation and approximate boundary layer methods, transition to turbulence, turbulent flow models, Reynolds stresses, Prandtl mixing length models, Turbulent pipe flows and boundary layers on smooth and rough surfaces, Overviews of flows around bodies, drag, lift and propulsion.

Text Books:

1. Franz Durst. Fluid Mechanics. Springer 1st Edition.
2. Frank White. Viscous Fluid Flow. McGraw-Hill, 3rd Edition.

Reference Books:

1. F S Sherman. Viscous Flow. McGraw-Hill.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand the fundamentals of fluid mechanics from an advanced point of view, with emphasis on the mathematical treatment of viscosity effects in laminar flows of a Newtonian fluid.
2. use the quite advanced mathematical ideas such as partial differential equation theory to analyse the underlying differential equations.
3. apply the knowledge of viscous flow problems for practical industrial problems.

ME 435	Mechanics of Composite Materials **B. Tech (Mechanical Engg.) Seventh Semester** **(Deptt. Elective–II)**	L T P C 3 1 0 4

Unit-1 Introduction: Classification of composite materials; Fibrous, laminated and particulate composites; Applications of composite materials.

Unit-2 Fabrication and characterization of Composite Materials: Properties of composite fibres; Fabrication of composites with thermosetting and thermo-plastic resin matrices, metal matrix and ceramic matrix; Experimental characterization of composites, such as uniaxial tension and compression, in-plane shear and bending strength, inter-laminar shear strength and fracture toughness; Damage identification using non-destructive techniques.

Unit-3 Macro and Micro mechanical behaviour of lamina: Stress-strain relations, engineering constants for orthotropic materials, transformation of stress and strain, strength and stiffness of an orthotropic lamina; Biaxial strength theories. Rule of mixture.

Unit-4 Strength of Composite Lamina - Macromechanics : Failure theories, Maximum stress theory, Maximum strain theory, Energy-based Interaction theory(Tsai-Hill), Interactive tensor polynomial theory(Tsai-Wu)

Unit-5 Macro mechanical behaviour of laminate: Single layered configurations, symmetric laminates, anti symmetric laminates; Strength of laminates; Inter laminar stresses, Hygrothermal analysis of both lamina as well as laminates.

Text Books:

1. B.D.Agarwal and L.J.Broutman. Analysis ***and Performance of Fiber Composites***. John Willey &Sons, Inc, 2nd edition.
2. I.M.Daniel and O.Ishai. ***Engineering Mechanics of Composite materials***. Oxford University Press.

Reference Books:

1. R.M.Jones. ***Mechanics of Composite Materials***. Mcgraw Hill Kogakusha, Ltd.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand the behaviour of composite materials under different loading conditions.
2. fabricate and characterize experimentally the fabricated composites.
3. design laminates for various structural components under different loading conditions.
4. perform stress and failure analysis of laminates.
5. understand the mechanisms of failure of composites.

ME 436	**Computer Aided Design**	**L T P C**
	B. Tech (Mechanical Engg.) Seventh Semester (Deptt. Elective–II)	**3 1 0 4**

Unit-1 Introduction to Computer Aided Design, Traditional Designing Vs. Computer Aided Design, Need for Computer Aided Design, Generalized procedure adopted in Computer Aided Design, Introduction to input devices, output devices, CAD Software's.

Unit-2 Homogeneous Coordinates and Transformations of geometry in plane and Space; Translation, Scaling, Reflection, Rotation, shear and Reflection Transformations. Scaling about an Arbitrary point, Rotation about an Arbitrary point and Line, Reflection in an Arbitrary Plane.

Projections and the Viewing Pipeline, Parallel Projections, Perspective Projections; the View plane Coordinate Mapping; the Viewing Pipeline

Unit-3 Introduction to Linear, Quadratic Cubic Bezier and higher degree Curves; Effect of Adjusting a Control Point; Properties of Low Degree Bezier Curves, Properties of the Bernstein Polynomials; De- Casteljau Algorithm, Subdivision of a Bezier Curve. Modelling of cubic spline, B-spline curves

and Non-uniform Rational B-Splines (NURBS).

Unit-4 Introduction Curves, Implicit and Explicit representation of Curves, Curve Rendering, Parametric representation of Curves, Advantages and Disadvantages,. Arc-length and Re-parametrization, Classification of Conics; Conics in Standard Form Intersections of a Conic with a Line.

Unit-5 Geometric Modelling of Surfaces: Basic surfaces entities, Surface of revolution, blends, intersections, modelling of analytical & sculptured surfaces.

Geometric Modelling of Solids: Solid entities, Boolean operations, 3-D Wire frame modelling, B-rep of Solid Modelling, CSG approach of solid modelling.

Unit-6 Data Exchange Formats such as IGES, STEP, and stl etc. - communication standards used in Finite element analysis, Rapid prototyping.

Text Books:

1. Ibrahim Zeid. ***Mastering CAD CAM***. Tata McGraw-Hill Publishing Co.
2. Donald Hearn and M. Pauline Baker. ***Principles of Computer Graphics***. Prentice Hall, Inc.

Reference books:

1. Duncan Marsh. ***Applied Geometry for Computer Graphics and CAD***. Second Edition Springer.
2. Rao, P.N. ***CAD / CAM Principles and Applications.*** McGraw Hill Publishers, New Delhi.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand the importance of CAD in the light of allied technologies such as CAM, CAE, FEA and CFD.
2. apply geometric transformations on the created wireframe, surface and solid models and solve numerical problems on transformation.
3. acquire fundamental knowledge on mathematical representation of curves and surfaces.

ME 438 **Refrigeration** **L T P C**

B. Tech. (Mechanical Engg.), Seventh Semester

Departmental Elective - II **3 1 0 4**

Unit-1 *Introduction:* History, Methods of refrigeration, Ice production, Units of refrigeration, Review of thermodynamics.

Unit-2 *Air Refrigeration System*: Carnot and Brayton cycles, Aircraft refrigeration systems - Simple, Boot-strap, Regenerative and reduced ambient system, Advantages and disadvantages.

Unit-3 *Vapour Compression System*: Analysis of simple cycles, Representation on T-s and p-h plot and its use, Methods of improving COP, Actual cycle, Introduction to compound compression and multiple evaporator system, Expression for COP and power required.

Unit-4 *Vapour Absorption System:* Theoretical analysis of VAR. system, Advantages and disadvantages, Practical VAR system, Aqua- ammonia and Lithium- Bromide- Water VAR systems.

Unit-5 *Refrigerants:* Nomenclature, Classification, Desirable properties, Environmental regulations, ODP, GWP.

Unit-6 *Other Refrigeration Systems*: Steam-jet, Thermoelectric, Vortex-tube, Pulse-tube, Magnetic, Piezo-electric refrigeration systems etc.

Unit-7 *Application of Refrigeration:* Domestic, commercial, industrial and medical refrigeration, Cold- storage, etc.

Text Books:

1. C. P. Arora, ***Refrigeration and Air conditioning***, McGraw Hill Education (India) Pvt. Ltd.
2. M. Prasad, ***Refrigeration and Air conditioning***, New Age International Publishers

Reference Books:

1. ASHRAE Hand Book Of Fundamentals, ASHRAE, USA
2. Stocker & Jones, Refrigeration and Air conditioning, McGraw Hill
3. Jordan & Preister: Refrigeration and Air conditioning, McGraw Hill
4. P. N. Ananthanarayan: Refrigeration and Air conditioning: TMH

Course Outcomes (COs):

Upon completion of this course, the students are expected to:

1. Identify different refrigeration systems with their working principles & practical applications in domestic, commercial and industrial sectors.

2. Evaluate the performances of various refrigeration systems like VAR, VCR, VAR systems by applying thermodynamic principles with fluid flow and heat and mass transfer fundamentals.
3. Classify the refrigerants with their nomenclature
4. Identify the important properties influencing refrigerant selection and to select refrigerant for a refrigeration system
5. Compare different refrigerants and suggest replacements for CFCs and HCFCs

ME 481 Battery and Fuel Cell Technologies L T P C

B. Tech (Mechanical Engg.) Seventh Semester
(Open Elective–II) **3 0 0 3**

Unit-1 Energy Resources, Energy Crisis, Need for Energy storage, Types of energy storage devices: Battery and Fuel cell etc.

Battery – Introduction to Battery Technology, Electrochemical Principles and Reactions, Factors Affecting Battery Performance

Unit-2 Primary Batteries (Zinc-Carbon Batteries, Magnesium and Aluminium Batteries, Alkaline-Manganese Dioxide Batteries, Mercuric Oxide Batteries, Button Cell Batteries: Silver Oxide–Zinc and Zinc-Air Systems, Lithium Primary Batteries), relative merits, demerits and application. Secondary batteries (Lead-Acid Batteries, Valve Regulated Lead-Acid Batteries, Iron Electrode Batteries, Iron Electrode Batteries, Vented Sintered-Plate Nickel-Cadmium Batteries, Portable Sealed Nickel-Cadmium Batteries, Nickel-Metal Hydride Batteries, Nickel-Zinc Batteries, Nickel-Hydrogen Batteries, Silver Oxide Batteries, Lithium-Ion Batteries, Rechargeable Lithium Metal Batteries, Rechargeable Zinc/Alkaline/Manganese Dioxide Batteries), relative merits, demerits and application.

Unit-3 Specialized Battery Systems (Batteries for Electric and Hybrid Vehicles, Batteries for Electrical Energy Storage Applications, Batteries for Biomedical Applications, Battery Selection for Consumer Electronics, Metal/Air Batteries, Reserve Magnesium Anode and Zinc/Silver Oxide Batteries, Reserve Military Batteries, Thermal Batteries), relative merits, demerits and application.

Unit-4 Battery Standardization and Design, Lithium-Ion Batteries, Battery optimization (Geometry, power and life), Mathematical Modeling of

Batteries, Future trends in Battery.

Unit-5 Fuel Cells- principle - working - thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery Vs fuel cell. Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits. Application of fuel cell and economics: Fuel cell usage for domestic power systems, large-scale power generation, Automobile, Space. Economic and environmental analysis on usage of Hydrogen and Fuel cell. Future trends in fuel cells.

Text Books:

1. Thomas B Reddy. ***linden's Handbook of Batteries***, McGraw-Hill.
2. John Newman, Karen E and Thomas-Alyea. ***Electrochemical Systems***, Wiley.
3. Reiner Korthauer. ***Lithium-Ion Batteries: Basics and Applications,*** Springer.
4. O'Hayre, R. P., S. Cha, W. Colella and F. B. Prinz. ***Fuel Cell Fundamentals***, Wiley.

Reference Books:

1. Supramaniam Srinivasan. ***Fuel cells: from fundamentals to applications***, Springer
2. B. Hart and G.J.Womack, ***Fuel Cells: Theory and Application***.
3. Viswanathan and M AuliceScibioh, ***Fuel Cells – Principles and Applications.***
4. L. Rebecca and Busby. Hydrogen ***and Fuel Cells: A Comprehensive Guide.***
5. Bent Sorensen. ***Hydrogen and Fuel Cells: Emerging Technologies and Applications.***

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. acquire knowledge of an array of topics in battery and fuel cells.
2. acquire technical depth to design and optimize battery and fuel cell system designs.
3. achieve a broad understanding of batteries and fuel cells applicable to practical problems in technological and physical research and development.

ME 482 Mechatronics L T P C

B. Tech (Mechanical Engg.) Seventh Semester
(Open Elective–II)

3 0 0 3

Unit-1 Introduction: Definition-Trends-Control Methods: Standalone, PC Based

(Real Time Operating Systems, Graphical User Interface, Simulation) - Applications: SPM, Robot, CNC, FMS, CIM.

Signal Conditioning: Introduction – Hardware - Digital I/O, Analog input – ADC, resolution, sped channels Filtering Noise using passive components – Resistors, capacitors - Amplifying signals using OP amps – Software - Digital Signal Processing – Low pass, high pass, notch filtering.

Unit-2 Precision Mechanical Systems: Pneumatic Actuation Systems - Electro-pneumatic Actuation Systems - Hydraulic Actuation Systems - Electro-hydraulic Actuation Systems - Timing Belts – Ball Screw and Nut - Linear Motion Guides - Linear Bearings - Harmonic Transmission - Bearings-Motor /Drive Selection.

Unit-3 Electronic Interface Subsystems: TTL, CMOS interfacing - Sensor interfacing – Actuator interfacing-solenoids, motors Isolation schemes-opto coupling, buffer IC's - Protection schemes – circuit breakers, over current sensing, resettable fuses, thermal dissipation - Power Supply – Bipolar transistors / MOSFETs.

Unit-4 Electromechanical Drives: Relays and Solenoids - Stepper Motors - DC brushed motors – DC brushless motors - DC servo motors - 4-quadrant servo drives, PWM's - Pulse Width Modulation – Variable Frequency Drives, Vector Drives - Drive System load calculation.

Unit-5 Microcontrollers Overview: Microcontroller, micro-processor structure – Digital Interfacing - Analog Interfacing - Digital to Analog Convertors - Analog to Digital Convertors–Applications. Programming–Assembly, C (LED Blinking, Voltage measurement by ADC).

Programmable Logic Controllers: Basic Structure - Programming: Ladder diagram - Timers, Internal Relays and Counters - Shift Registers - Master and Jump Controls - Data Handling - Analog input / output - PLC Selection - Application.

Programmable Motion Controllers: Introduction - System Transfer Function – Laplace transform and its application in analysing differential equation of a control system – Feedback

Unit-6 Devices: Position , Velocity Sensors - Optical Incremental encoders - Proximity Sensors: Inductive , Capacitive, Infrared-Continuous and

discrete processes - Control System Performance & tuning - Digital Controllers - P, PI, PID Control - Control modes – Position, Velocity and Torque - Velocity Profiles – Trapezoidal - S. Curve - Electronic Gearing - Controlled Velocity Profile - Multi axis

Interpolation, PTP, Linear, Circular - Core functionalities – Home, Record position, Go to Position - Applications : SPM, Robotics.

Text Books:

1. Mahalik. ***Mechatronics.*** McGraw-Hill.
2. W Bolton. ***Mechatronics Electronics Control Systems in Mechanical and Electrical Engg.*** Pearson Edu. Press, 3rd Ed.
3. M.D.Singh and J.G.Joshi. ***Mechatronics***. PHI.

Reference Books:

1. Newton C Braga. ***Mechatronics Source Book.*** Thomson Publications, Chennai.
2. N. Shanmugam and Anuradha. ***Mechatronics.*** Agencies Publishers.
3. Devdas shetty and Richard. ***Mechatronics System Design***. Thomson.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand the concept of mechatronics.
2. identify, select, and integrate mechatronic components to meet product requirements.
3. build a mechatronic system with an integrated computer control using actuators, controls, and mechanical system elements.
4. gain the fundamental knowledge of robots and automation.
5. have hand-on skills in developing basic mechatronic products.

ME 483 Uncertainty Quantification L T P C

B. Tech (Mechanical Engg.) Seventh Semester
(Open Elective–II)

3 0 0 3

Unit-1 Introduction – Basics of Uncertainty, Classification of Uncertainty, Indeterminacy, Frequency, Belief Degree, Sources of Uncertainty, Propagation of uncertainty, Uncertain Logic, Uncertain Inference,

Uncertain Process, Probability theory and Chance theory, Model calibration, Surrogate models, Parameter selection, Sensitivity Analysis, Various Applications including large scale (Big-Data) of system uncertainty, Effect of noise.

Unit-2 Uncertainty Measures - Measurable Space, Uncertain space, Independence, Polyrectangular theorem, Conditional Uncertain Measure.

Unit-3 Uncertain Variable – Variables, Distribution, Operational Laws, Expected value, Variance, Moment, Entropy, Distance, Conditional Uncertainty Distribution, Uncertain Sequence, Uncertain Vector.

Unit-4 Uncertain Programming - Numerical Method, Machine Scheduling Problem, Multi-objective Programming, Goal Programming, Multilevel Programming.

Unit-5 Uncertainty Modeling methods and Sampling Techniques – Deterministic and Non-deterministic Approach, Probabilistic and Non-probabilistic modeling, Fuzzy model, High dimensional model representation, Response Surface methods, Random variable and Random field Approach, Kriging model, Model reduction, Various Sampling and optimization techniques and Solutions.

Text Books:

1. T.J. Sullivan. ***Introduction to Uncertainty Quantification***. Springer.
2. Ralph C. Smith. ***Uncertainty Quantification: Theory, Implementation, and Applications***.SIAM.
3. Eduardo Souza de Cursi and Rubens Sampaio. ***Uncertainty Quantification and Stochastic Modeling with Matlab*** . Springer

Reference Books:

1. S. Dey, T. Mukhopadhyay and S. Adhikari. ***Uncertainty Quantification in Composite Structures – A Metamodel Based Approach***. CRC Press.
2. Roger Ghanem, David Higdon and Houman Owhadi (Eds.). ***Handbook of Uncertainty Quantification.*** Springer

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. gain the fundamental knowledge of uncertainty quantification with its significance and applications in various real-life systems

2. identify the sources of uncertainty in any engineering system
3. develop the skill in mapping the propagation of uncertainty in any system
4. gain knowledge in quantifying the uncertainties in the system

ME 484	Hydraulic Machines	L T P C
	B. Tech (Mechanical Engg.) Seventh Semester (Open Elective–II)	**3 0 0 3**

Unit-1 Principles of Hydraulic Machines:-

Impulse momentum equation, Impact of jet on flat and curved vanes, Euler`s equation of turbo- machines, Jet propulsion of ships

Unit-2 Hydro-electric Developments:-

Water wheels- their types and working principles, Development of water turbines- their classifications and working principles, Hydro-electric plants- their classification, essential components and layouts, Advantages of hydro- electric plants, Pumped storage plants

Unit-3 Impulse Turbines: -

Power produced by impulse turbine, Efficiencies of an impulse turbine, Design of Pelton wheel turbine, power and efficiency, Other impulse turbines.

Reaction Turbines:-

Differences between an impulse and a reaction turbine, Classification of reaction turbines, Power produced by a reaction turbine, Efficiencies of reaction turbine, Francis turbine, Kaplan turbine, Cavitation in reaction turbines, Draft tubes, Other reaction turbines.

Performance of Turbines: -

Characteristic of turbines, Unit power, Unit speed and unit discharge, Specific speed of a turbine- their significances, Selection of turbines based on Head of water and also based on specific speed, Characteristic curves of turbines

Unit-4 Governing of Turbines: -

Purpose of governing, Elements of governing system, Double regulation of turbines, Governing of impulse turbines, Governing of reaction turbines.

Unit-5 Hydraulic Pumps:

Pumps and its classification, Reciprocating pump- types, discharge and power required, Slip of the pump, Indicator diagram, Maximum speed of the rotating crank with air vessels, Work done against friction with or without air vessels, Work saved against friction

Centrifugal Pump- Advantages of centrifugal pump over reciprocating pump, Components of centrifugal pump, Working of a centrifugal pump, Heads of pumps, Losses and efficiencies, Multistage centrifugal pumps, Specific speed, Characteristic of a centrifugal pump, Priming, Minimum starting speed, Selection of pumps, operational difficulties in centrifugal pumps.

Unit-6 Hydraulic Devices:-

Hydraulic accumulator, Hydraulic intensifier, Hydraulic press, Hydraulic coupling, Torque converter, Hydraulic brakes, Hydraulic cranes

Text Books:

1. Jagdish Lal, ***Hydraulic Machines,*** Metropolitan Publication.
2. R.K. Bansal, ***Fluid Mechanics & Hydraulic Machines***, Laxmi Publication, 9th Ed.

Reference Books:

1. Vasandani, ***Hydraulic Machines Theory & Design***, Khanna Publishers.
2. S.S. Rattan, ***Fluid Machines***, Khanna Publishers.

Course outcomes (COs):

Upon the completion of this course, the students are expected to:

1. identify the layout, design and operations of different hydroelectric power plants.
2. identify the design and learn operating principle of different types of hydraulic pumps, turbines and devices present in the industry.
3. identify and select a proper hydraulic machine or device for a given operating condition and application, and thus will have a successful professional carrier.

ME 451	Computer Integrated Manufacturing **B. Tech (Mechanical Engg.) Eighth Semester** **(Deptt. Elective–III)**	**L T P C** **3 0 0 3**

Unit-1 Introduction: Fundamental concept in manufacturing and automation, fundamental of CAD/CAM, need of CAD,CAM, and CIM, automation in CAD/CAM and CAD/CAM integration.

Unit-2 Group Technology (GT): Introduction, part families, parts classification and coding systems, GT machine cells, benefits of GT. Process Planning: Basic concepts of process planning, computer aided process planning (CAPP), Retrieval or variant and generative approach of CAPP, Implementation consideration of CAPP.

Unit-3 Numerical Control of Machine Tools: Principles of Numerical control (NC), Computer Numerical control (CNC), Direct Numerical control (DNC), comparison between conventional and CNC systems, Classification of CNC system, NC coordinate system, positional control, system devices, interpolators, adaptive control system.

NC Part Programming: Concept, format, preparatory and miscellaneous codes, manual part programming, APT programming.

Unit-4 FMS and CIM: Introduction to flexible manufacturing system (FMS), the manufacturing cell, tool management and workpiece handling system, transfer lines, types and application of industrial robots, end effectors and grippers of robots, types of manufacturing systems, components of computer integrated manufacturing (CIM), benefits of CIM.

Unit-5 Shop floor control: automatic identification methods, barcode technology, automated data collection system.

CIM data base and communication: Introduction to data base, database management, Communicate on fundamentals, local area networks, network management and installation. Role of management in CIM

Text Books:

1. Mikell P.Groover. ***Automation, Production systems and Computer Integrated Manufacturing Systems.*** PHI Publishers.
2. Mikell P.Groover and Emory W.Zimmers.Jr. ***CAD/CAM***, PHI Publishers.

3. K.Lalit Narayan, K. MallikarjunaRao and MMM Sarcar. ***Computer Aided Design and Manufacturing.*** PHI Publishers.

Reference Books:

1. Radhakrishnan and Subramanian. ***CAD/CAM/CIM***. New Age Publishers.
2. Chang, T. C., Wysk, R. A. and Wang, H. P. ***Computer aided Manufacturing***. Prentice Hall.
3. Nanua Singh. Systems ***Approach to Computer Integrated Design and Manufacturing.*** John Wiley and Sons Ltd.

Course outcomes (COs):

Upon the completion of this course, the students are expected to:

1. Understand the use of computer in manufacturing, automation and robotics.
2. learn the working of NC, CNC and DNC machine and use of CAPP in manufacturing environment.
3. design flexible manufacturing cell after carrying out group technology study and finally creating FMS.
4. apply knowledge about various methods of communication in CIMS.
5. apply data base management and its importance for decision making in CIMS environment.

ME 452 Condition Monitoring of Manufacturing Processes L T P C

B. Tech (Mechanical Engg.) Eighth Semester
(Deptt. Elective–III) **3 0 0 3**

Unit-1 Introduction: Introduction to monitoring concept, need for monitoring, techniques used in monitoring of manufacturing processes, elements of monitoring framework, offline and online monitoring, advantages and disadvantages of monitoring

Unit-2 Sensors and actuators: sensor definition and types, sensors for various applications, selection of sensors, sensor characteristics, applications of sensors, actuator definition and types, selection of actuators, actuator characteristics, applications of actuator.

Unit-3 Data acquisition and signal processing: Data acquisition techniques,

different systems for data acquisition, data sampling and sampling characteristics, signal characteristics, signal pre and post processing, feature extraction, statistical signal processing, time domain and frequency domain analysis of signals, Fourier transform, wavelet transform.

Unit-4 Control System: Introduction to control systems, types of control systems, PI/PD/PID control system characteristics, stability of control systems, applications of various control systems.

Unit-5 Monitoring of manufacturing processes: Techniques for monitoring of welding, machining, forming, casting and advanced manufacturing processes. Advancements in condition monitoring practices: Recent developments in monitoring practices, smart sensor, image processing based monitoring, data modelling through artificial intelligence.

Text Books:

1. R. Mohanty. ***Machinery Condition Monitoring: Principles and Practices***. CRC Press
2. R. B. Randall. ***Vibration–based Condition Monitoring: Industrial, Aerospace and Automotive Applications.*** Willey.
3. K. Ogata. ***Modern Control Engineering.*** PHI.

Reference Books:

1. A.V.Opponheim, A.S.Willsky and Nawab. ***Signals and Systems***.
2. S K Mitra. ***Digital Signal Processing***. TMH.
3. C. W. Silva. ***Sensors and Actuators: Engineering System Instrumentation***. CRC Press.
4. D. Patranabis. ***Sensors and Transducers***.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. get knowledge of monitoring concept in manufacturing processes, its advantages and disadvantages.
2. gain knowledge base learning for applications of various sensors, actuators, and data handling systems for monitoring of various manufacturing processes.
3. understand the role of control system on process monitoring in general and on manufacturing processes in specific.
4. develop different methodologies for monitoring of manufacturing processes.

ME 453	Engineering Fracture Mechanics B. Tech (Mechanical Engg.) Eighth Semester (Deptt. Elective–III)	L T P C 3 0 0 3

Unit-1 Introduction and historical review, Sources of micro and macro cracks. Stress concentration due to elliptical hole, Strength ideal materials, Griffith's energy balance approach. Fracture mechanics approach to design. The Airy stress function. Complex stress function. Effect of size. Special cases, Elliptical cracks.

Unit-2 Plasticity effects, Irwin plastic zone correction. Dugdale approach. The shape of the plastic zone for plane stress and plane strain cases, Plastic constraint factor. The Thickness effect, determination of Stress intensity factors and plane strain fracture toughness: Introduction, estimation of stress intensity factors. Plane strain fracture toughness test, The Standard test. Size requirements. Non-linearity. Applicability

Unit-3 The energy release rate, Criteria for crack growth. The crack resistance (R curve). Compliance, J integral, CTOD. Tearing modulus. Stability. Elastic plastic fracture mechanics: Fracture beyond general yield. Ductile and Brittle Fracture.

Unit-4 Fatigue Fracture: Paris law, life time prediction, Persistent slip band, Stress corrosion cracking. Mixed mode (combined) loading and design criteria.

Text Books:

1. Anderson T.L. ***Fracture Mechanics, Fundamentals and Applications***. 2nd Edition, CRC Press, (1995).
2. Broek, D. Elementary ***Engineering Fracture Mechanics.*** Kluwer Academic Publishers, Dordrecht, (1986).

Reference Books:

1. Knott. ***Fundamentals of fracture mechanisms***. Butterworths, (1973).
2. Rolfe and Barsom. ***Fracture and Fatigue Control in Structures***, Prentice Hall, (1977).

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. develop basic fundamental understanding of the effects of crack like defects on the performance of aerospace, civil, and mechanical Engineering structures.

2. select appropriate materials for engineering structures to insure damage tolerance.
3. employ modern numerical methods to determine critical crack sizes and fatigue crack propagation rates in engineering structures.
4. gain an appreciation of the status of academic research in field of fracture mechanics.

ME 454 Heat Transfer Application in Biological Systems L T P C

B. Tech (Mechanical Engg.) Eighth Semester
(Deptt. Elective–III)

3 0 0 3

Unit-1 Introduction to Biological Systems: Human body – Physiological aspects – Biothermofluidics: Renal System, Blood Circulation and Lungs – Heat Transfer and Temperature Distribution in the Human body – Mass, energy, and flow transport in biosystems

Unit-2 Heat transfer modeling: Introduction, fundamental aspects of bioheat transfer, bioheat transfer modelling, temperature, thermal property, and blood flow measurements,

Unit-3 Bioheat equations: The Pennes biioheat equation, Wulff continuum model, Klinger continuum model Weinbaum-Jiji bioheat transfer models, Bioheat equation on skin tissues with different boundary conditions, non-Fourier and Fourier bioheat transfer analysis during laser irradiation of skin tissue.

Unit-4 Application of bioheat equations for various treatments/injury: hyperthermia treatment for cancers and tumors, eye surgery, skin burn injury induced by radiation heating, coffee spill burning etc

Text Books:

1. Majid Ghassemi, and Azadeh Shahidian: ***Nano and Bio Heat Transfer and Fluid Flow:*** Academic Press
2. Arthur T. Johnson: ***Biological Process Engineering: An Analogical Approach to Fluid Flow, Heat Transfer, and Mass Transfer Applied to Biological Systems:*** Wiley-Interscience

Reference Books:

1. Aziz: ***Conduction heat transfer***: John Wiley & Sons Inc
2. R. C. Seagrave: ***Biomedical applications of heat and mass transfer:*** Iowa State University Press,(1971)

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. describe physiological aspects of human body.
2. perform modelling of bio heat equation with different boundary conditions.
3. apply the concept of bio heat equation in real life applications.

ME 455	Mechanical Vibration	L T P C
	B. Tech (Mechanical Engg.) Eighth Semester	
	(Deptt. Elective–III)	**3 0 0 3**

Unit-1 Basics of Vibration: Properties of simple harmonic motion; Introducing the term natural frequency; Nature and types of dynamic loading; Introduction Scope and objective, Essential elements of a vibrating system Importance of Mechanical Vibration.

Unit-2 Vibration of elementary systems: Degrees of freedom free vibrations of undamped system. Drawing free body diagrams and deriving equations of motion using Newton –Euler method, D'Alembert's method, Energy method, and Rayleigh's method; Undamped and damped free and forced vibrations

Unit-3 Free Vibration: Study of free vibrations of spring mass damper system. Concepts of critical damping coefficient and damping factor. Under damping, critical damping and over damping.

Forced vibration: Forced vibration due to support motions; Rotating mass and constant force oscillators; Non harmonic forced vibrations; Study of vibrations of undamped system under harmonic excitation. Effect of frequency of excitation on the amplitude of vibrations. Magnification Factor. Phase difference between excitation and motion. Dependence of Magnification Factor and Phase difference on frequency of excitation. Vectorial representation of forces in a vibrating system. Physical reasoning of effect of various elements in the system. Force Transmissibility, Motion Transmissibility, and vibration absorbers.

Unit-4 Two degree of freedom systems: Formulation of equation of motion: Equilibrium method, Lagrangian method, Eigen values and Eigen vectors, Normal modes and mode superposition, Coordinate coupling, decoupling

of equations of motion, Natural coordinates, Response to initial conditions, free vibration response and Forced vibration response, Whirling of shafts. Critical speed and its practical importance in the design of shafts.

Unit-5 Multi-degree of freedom systems: Basics of MDOF, Application of Dunkerley's method and Rayleigh's method for estimating the critical speed of shafts. Response analysis to determine natural frequency of Single, Two, Three rotor and multi degrees of freedom systems of Torsional vibration system with uniform and stepped shaft.

Unit-6 Continuous systems: Introduction to continuous systems, Exact and approximate solutions, free vibrations of bars and shafts, Free vibrations of beams, Forced vibrations of continuous systems, Wave Propagation: Elastic response of continua to establish one, two and three dimensional wave equations.

Text Books:

1. S. Graham Kelly. ***Fundamentals of Mechanical Vibrations***: 2nd Edition Mc-Grawhill (2000).
2. William J. Bottega. ***Engineering Vibrations***. CRC Taylor & Francis Group London New York (2006)**.**
3. C. F. Beards. ***Engineering Vibration Analysis with Application to Control Systems.*** Edward Arnold Great Britain (1995)

Reference Books:

1. Singiresu S Rao. ***Mechanical Vibrations***. 4th Ed. , Pearson education (2011)
2. W.T., Thompson. ***Theory of Vibration***. CBS Publishers
3. Daniel J. Inman. ***Engineering Vibration.*** Fourth Edition Pearson education (2014)

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand the basics and causes and effects of vibration in mechanical systems.
2. develop and derive mathematical modeling and formulate governing equations for discrete and continuous system.
3. comprehend and analyze the role of damping, stiffness and inertia in mechanical vibratory systems.

4. design and analyze rotating and reciprocating systems and compute critical speeds.
5. analyze and design machine supporting structures, vibration isolators and absorbers.

ME 456	Two Phase Flow	L T P C
	B. Tech (Mechanical Engg.) Eighth Semester (Deptt. Elective–III)	**3 0 0 3**

Unit-1 Introduction: Formulation and Solution to Phase Change Problem, Two Phase Flow Fundamentals, Review of one dimensional conservation equations in single phase flows; Governing equations for homogeneous, separated and drift-flux models; Flow pattern maps for horizontal and vertical systems; Simplified treatment of stratified, bubbly, slug and annular flows.

Unit-2 Modeling of Two-Phase Flow: Pressure Drop in Two-Phase Flow, Brief Discussion on Critical Flow and Unsteady Flow.

Unit-3 Boiling: Description and Classification of Boiling, Pool Boiling Curve, Nucleation and Dynamics of Single Bubbles, Heat Transfer Mechanisms in Nucleate Boiling, Nucleate Boiling Correlations, Hydrodynamic of Pool Boiling Process, Pool Boiling Crisis, Film Boiling Fundamentals, Flow Boiling, Forced-Flow Boiling Regimes, Flow Boiling Curves, Nucleate Boiling in Flow, Sub-cooled Nucleate Flow Boiling, Saturated Nucleate Flow Boiling, Flow Boiling Correlations, Flow Boiling Crisis. Condensation- Film and drop-wise condensation.

Text Books:

1. S. Mostafa Ghiaasiaan. ***Two-Phase Flow, Boiling And Condensation in Conventional and Miniature Systems.*** Cambridge University Press, (2008).
2. L. S. Tong and Y. S. Tang. ***Boiling Heat Transfer and Two-Phase Flow***. Taylor and Francis, (1997).
3. E. Y. Bormashenko and De Gruyter. ***Physics of Wetting*** (2017).

Reference Books:

1. De Gennes, Brochard-Wyart and Quere. ***Capillarity and Wetting Phenomena: Drops, Bubbles, Pearls, Waves***. Springer (2004).

2. Gioia Falcone and Geoffrey F Hewitt. ***Multiphase flow metering***. Elsevier Science (2009).
3. Christopher Brennen. ***Fundamentals of Multiphase Flow***. (2005)**.**
4. Prosperetti and Tryggvason. ***Computational Methods for Multiphase Flow***. Cambridge

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. describe the most important phenomena and principles of two-phase flow in engineering applications.
2. explain the main points of boiling and condensation, heat transfer, and their enhancement methods.
3. describe the concept boiling crisis (e.g., DNB - departure from nucleate boiling, and dryout).
4. apply the basic two-phase models and flow pattern maps to calculate the pressure drops of two-phase flow at various conditions.
5. apply the models of critical flow and flooding to analyze limiting flow of engineering processes.

ME 457	**Air-Conditioning**	**L T P C**
	B. Tech. (Mechanical Engg.), Eighth Semester	
	Departmental Elective - III	**3 0 0 4**

Unit-1 *Introduction:* Basics of Psychometry, Psychrometric properties, Representation of psychrometric properties in charts, Preparation of psychrometric chart.

Unit-2 *Psychrometric Processes:* Basic psychrometric processes, Sensible and latent heat processes, Adiabatic saturation, Adiabatic mixing of air streams, Air-Washer, Sensible heat factors, Apparatus dew point, By pass factor, Humidifying efficiency.

Unit-3 *Basic Air-Conditioning Systems*: Summer air-conditioning systems with and without ventilation, Winter air-conditioning systems.

Unit-4 *Load Calculations:* Load classification, Components of cooling load and heating load, Cooling/heating load estimation methods, Estimation of cooling/heating load.

Unit-5 *Inside and outside design conditions:* Fixing of inside and outside design conditions, Conditions for human comfort, Comfort parameters, Comfort Indices, Comfort charts.

Unit-6 *Air Transmission Systems:* Pressure drop calculation for various types of duct,

Enlargements, Contractions, Branch tube- offs etc., Duct design methods, Duct design procedure.

Unit-7 *Room Air Distribution Systems:* Air distribution terminology, Types of supply air outlets and return air inlets, Selection of supply air outlets and return air inlets, Air distribution patterns for different types of supply air outlets in summer and winter conditions.

Unit-8 *Air Conditioning Systems:* Central and unitary air conditioning, Special features of residential, commercial and industrial air conditioning system, Year round air conditioning.

Text Books:

1. C. P. Arora, ***Refrigeration and Air conditioning***, McGraw Hill Education (India) Pvt. Ltd.
2. M. Prasad, ***Refrigeration and Air conditioning***, New Age International Publishers

Reference Books:

1. ASHRAE Hand Book Of Fundamentals, ASHRAE, USA
2. Stocker & Jones, Refrigeration and Air conditioning, McGraw Hill
3. Jordan & Preister: Refrigeration and Air conditioning, McGraw Hill
4. P. N. Ananthanarayan: Refrigeration and Air conditioning: TMH

Course Outcomes (COs):

Upon completion of this course, the students are expected to:

1. apply thermodynamic principles to perform psychrometric calculations,
2. apply heat transfer principles in evaluating the performance of simple air conditioning systems,
3. synthesize psychrometric system design for air conditioning systems,
4. apply principles of fluid flow and heat transfer to design air transmission system,
5. interpret comfort indices for determination parameters involving design with respect to comfort air conditioning,
6. explain the importance of proper air distribution, draw air-flow patterns for different air diffusers and list the criteria for selecting supply and return air outlets.

ME 491 Interfacial Instability and Applications

B. Tech (Mechanical Engg.) Eighth Semester
(Open Elective–III)

L T P C
3 0 0 3

Unit-1 Introduction: Basic principles of interfacial instability, Basic spray processes, Factors cont rolling breakup of jet and spray formation.

Unit-2 Sheet and ligament breakup: Instability analysis for ligaments and sheet, design models based on instability analysis.

Unit-3 Drop formation: Static and dynamic force balances, continuity consideration, secondary atomization, collision and coalescence.

Drop motion and spray-surroundings interactions: Steady trajectories (gas turbines, spray cooling, paint sprays), Entrainment.

Unit-4 Atomizer performance: Modern design models for pressure-swirl atomizers, impinging jet atomizers, transient pressure (Diesel) atomizers.

Unit-5 Measurement techniques: Drop sizing by Malvern and P/DPA, Drop velocity by P/DPA, Mass flux distribution by patternators and P/DPA.

Text Books:

1. Cengel and Cimbala. ***Fluid Mechanics.*** Tata McGraw Hill
2. G.K. Batchelor. ***An Introduction to fluid Dynamics.*** Cambridge University Press.

Reference Books:

1. A.H. Lefebvre. ***Atomization and Sprays***. Hemi sphere: New York, (1989)**.**
2. L. Bayvel and Z. Orzechowski. ***Liquid Atomization.*** Taylor and Francis: Washington DC, (1993).

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand the various practical application of interfacial instability jet breakup and spray formation.
2. get a basic knowledge of droplet distribution and spray characteristics.
3. gain a basic understanding on working principle of various atomizers.

ME 492 MEMS and Nanotechnology L T P C

B. Tech (Mechanical Engg.) Eighth Semester
(Open Elective–III) **3 0 0 3**

Unit-1 Introduction: Overview of MEMS and microsystems, microelectronics, microfabrication, miniaturization, typical MEMS and microsystems products. Working principles of microsystems: microsensors, microactuation, MEMS with microactuators, microfluidics, microvalves,

micropumps, micro-heat pipes.

Unit-2 Overview of materials for MEMS and microsystems: atomic structure of matter, ions and ionization, doping of semiconductors, diffusion process, electrochemistry.

Unit-3 Microsystem fabrication: photolithography, ion implantation, diffusion, oxidation, chemical vapor deposition, physical vapor deposition, sputtering, etching. Micro-manufacturing: bulk micro-manufacturing, surface micro-manufacturing, LIGA process.

Unit-4 Assembly, packaging and testing of microsystems: overview of microassembly, microassembly processes, major technical problems of microassembly, microsystem packaging and its levels, essential packaging technologies, reliability and testing in MEMS packaging.

Unit-5 Nanotechnology: Introduction, introduction to physics of the solid state, properties of individual nano particles, carbon nano-tubes, and bulk nano structured materials.

Text Books:

1. Mahalik: ***MEMS.*** McGraw-Hill, 1/e.
2. Tai-Ran Hsu. ***MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering.*** McGraw-Hill**.**
3. Pradeep. ***A Textbook of Nanoscience and Nanotechnology.*** McGraw-Hill, 1/e**.**
4. N. P. Mahalik. ***Micromanufacturing and Nanotechnology***. Springer

Reference Books:

1. Nadim Maluf and Kirt Williams. ***An Introduction to Microelectromechanical Systems Engineering***. Artech House, Inc.
2. Mark Ratner and Danier Ratner. ***Nanotechnology.*** Pearson Education Inc.
3. Charles P. Poole Jr. And Frank J. Owens. ***Introduction to Nanotechnology.*** John Wiley & Sons, Inc.
4. Roger, Pennathur and Adams. ***Nanotechnology Understanding Small systems.*** CRC Press.
5. Stephen Beeby, Graham Ensell, Michael Kraft and Neil White. ***MEMS Mechanical Sensors.*** Artech House, Inc.
6. Mohamed Gad-el-Hak. ***MEMS Introduction and Fundamentals.*** CRC Press

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. identify the applications of MEMS and nanotechnology.
2. describe the working principles of microsystems.
3. select the appropriate materials and processes for MEMS fabrication.
4. prescribe suitable testing, assembling, packaging and handling techniques.

ME 493	Microscale Transport Processes B. Tech (Mechanical Engg.) Eighth Semester (Open Elective–III)	L T P C 3 0 0 3

Unit-1 Introduction: Origin, Definition, Benefits, Challenges, Physics of miniaturization, Scaling laws.

Unit-2 Micro-scale fluid mechanics: Intermolecular forces, States of matter, Continuum assumption, Governing equations, Constitutive relations, Gas and liquid flows, Boundary conditions, Slip theory, Transition to turbulence, Low Reynolds number hydrodynamics, Entrance effects, Exact solutions, Viscous heating and entropy generation in channel flows, Stokes drag on a sphere, Time-dependent flows, Two-phase flows, Straight channel of different cross-sections, Channels in series and parallel.

Unit-3 Surface tension driven flows: Surface tension and interfacial energy, Young-Laplace equation, Contact angle, Capillary filling dynamics, Modulating surface tension, Electro-capillary effects, Continuous electro-wetting, Direct electro-wetting, Electro-wetting on dielectric.

Unit-4 Electrokinetics: Electrohydrodynamics fundamentals, Electro-osmosis, Debye layer, Thin Electric double layer limit, Ideal electro-osmotic flow, Ideal electro-osmotic flow with back pressure, Electro-osmotic flow of power-law fluids. Electrophoresis of particles, Electrophoretic mobility, Electrophoretic velocity dependence on particle size. Dielectrophoresis, Induced polarization and DEP , Point dipole in a dielectric fluid, DEP force on a dielectric sphere, DEP particle trapping, AC DEP force on a dielectric sphere.

Unit-5 Micro-mixing**:** Chaotic micro-mixing and its characterization

Micro-fabrication: Materials, Clean room, Silicon crystallography,

Oxidation, photolithography- mask, spin coating, exposure and development, Etching, Bulk and Surface micromachining, Wafer bonding. Polymer microfabrication, PMMA//PDMS substrates, micromolding, hot embossing.

Text Books:

1. Terrence Conlisk. ***Essentials of Micro-and Nanofluidics.*** Cambridge University Press.
2. Dongqing Li. ***Encyclopedia of Microfluidics and Nanofluidics***. Springer.
3. S. Chakraborty. ***Microfluidics and Microscale Transport Processes.*** CRC Press.

Reference Books:

1. S. Mitra and S. Chakraborty (Editors). ***Handbook of Microfluidics and Nanofluidics.*** CRC Press.
2. H. Bruss. ***Theoretical Microfluidics.*** Oxford University Press.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. differentiate the microscale transport characteristics from that of macroscale.
2. analyze surface tension driven flows.
3. solve problems involving electrokinetic flows.
4. develop solutions for micro-mixing.
5. fabricate microchannel/devices and conduct experiments on those channels/devices and analyse the results.

ME 494 Pollution Control and Management

B. Tech (Mechanical Engg.) Eighth Semester
(Open Elective–III)

L	T	P	C
3	0	0	3

Unit-1 *Introduction*: Global atmospheric change, greenhouse effect, Ozone depletion, natural cycles, mass and energy transfer, material balance, environmental chemistry and biology, impacts, environmental. Legislations.

Unit-2 *Air pollution*: Pollutants, sources and effect, air pollution meteorology, atmospheric dispersion, indoor air quality, control methods and equipment's, issues in air pollution control, air sampling and measurement.

Unit-3 *Water pollution*: Water resources, water pollutants, characteristics, quality, water treatment systems, waste water treatment, treatment, utilization and disposal of sludge, monitoring compliance with standards.

Unit-4 *Waste management*: Sources and Classification, Solid waste, Hazardous waste, Characteristics, Collection and Transportation, Disposal, Processing and Energy Recovery, Waste minimization.

Unit-5 *Other types of pollution from industries*: Noise pollution and its impact, oil pollution, pesticides , instrumentation for pollution control , water pollution from tanneries and other industries and their control, environment impact assessment for various projects, case studies

Text Books:

1. G. Masters. ***Introduction to Environmental Engineering and Science.*** Prentice Hall of India Pvt Ltd, New Delhi, (2013)**.**
2. H.S.Peavy, D.R..Rowe and G.Tchobanoglous. ***Environmental Engineering***. McGraw, Hill Book Company, NewYork, (1985).

Reference Books:

1. H.Ludwig and W.Evans. Manual ***of Environmental Technology in Developing Countries***. International Book Company, Absecon Highlands, N.J, (1991)**.**
2. Arcadio P Sincero and G. A. Sincero. ***Environmental Engineering, A Design Approach.*** Prentice Hall of India Pvt Ltd, New Delhi (2002)

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. understand key current environmental problems.
2. identify and value the effect of the pollutants on the environment: atmosphere, water and soil.
3. analyse an industrial activity and identify the environmental problems.
4. plan strategies to control, reduce and monitor pollution.
5. select the most appropriate technique to purify and/or control the emission of pollutants.
6. apply the basis of an Environmental Management System (EMS) to an industrial activity.
7. gain knowledge of basic environmental legislation.

ME 495	Solar Architecture	L T P C
	B. Tech (Mechanical Engg.) Eighth Semester	
	(Open Elective–III)	**3 0 0 3**

Unit-1 Thermal Comfort: General introduction, Parameters governing thermal comfort, Heat exchange of body with environment, various comfort indices, Psychometric and psychometric chart, Comfortchart.

Unit-2 Climate & Solar Nomenclature: Climate change due to land, water, wind etc. Classification of climates, Sun motion, solar angles and their relationships, Calculation of solar radiation intensities, Basic solar collectors, Shading devices.

Unit-3 Building with Solar Exposures: Various building forms and surface areas, Mutual shading of buildings, Building orientations with respect to sun, Efficiencies of building forms, Building fenestration and its effect.

Unit-4 Passive Concepts & Components: Passive heating concepts- direct gain, indirect gain, sun space andindirect gain, Passive cooling concepts – minimization of beam radiation, Thick walls and roofs,Evaporative cooling, Radiative cooling, Cavity walls, Exploitation of wind, water earth for cooling, Sky therm, Vary therm wall, Earth shattered structure, Earth – air tunnels, Ventilation components.

Unit-5 Heat Transfer in Buildings: Modes of heat transfer- basic concepts, Surface coefficients, overall thermal transmittance for various walls and roofs, Heat transfer due to ventilation/infiltration, intermittent heat transfer.

Unit-6 Mathematical Modelling of Passive Concepts: Approximate methods- degree day method, steady state method, Correlation methods, Analytical methods- thermal circuit analysis, Finite difference approach, response factor method, periodic solution method.

Unit-7 Evaporative Cooling: Historical background, Basic principle and classification, Climate conditions, Direct types of E.C, Indirect type of E.C, 2- stage E.C, Earth cooling, Earth air tunnel systems.

Unit-8 Typical Design of Solar Passive Buildings: Case studies – For cold climate- the hedge type, ware house type, solarium and trombe wall type etc. For tropical climate – skytherm systems, for arid climate and for humid climate

Text Books:

1. M. S. Sodha, N. K. Bansal and A. Kumar. Solar ***Passive Building- Science & Design.***
2. N.K. Bansal & G. Hanser: ***Passive Building Design- A Hand Book of Natural Climate Control.***
3. C.P. Arora. ***Refrigeration and Air conditioning.***

Reference Books:

1. Ashrae. ***Ashrae Hand Book of Fundamentals.***
2. Duffie and Beckman. ***Solar Engineering of Thermal Processes.*** Wiley publications.

Course Outcomes (COs):

Upon the completion of this course, the students are expected to:

1. apply the heat transfer principles for the design of solar passive building.
2. design passive solar building in various climatic conditions
3. perform mathematical modelling of passive concepts for building installations.
4. understand the designs and operations of various solar collectors.
5. calculate solar angles and solar radiation intensities for various climatic conditions.

****