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.

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

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** **B. Tech (Mechanical Engg.) Sixth Semester** **(Deptt. Elective – I)**	**L T P C** **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

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

L T P C
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 B. Tech (Mechanical Engg.) Sixth Semester (Open Elective – I)	L T P C 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 B. Tech (Mechanical Engg.) Seventh Semester (Deptt. Elective–II)	L T P C 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

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

L	T	P	C
3	1	0	4

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 437 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 438 Additive Manufacturing L T P C

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

(Departmental Elective II)

Unit-1 Introduction: Overview, History, Classification, Subtractive vs Additive Manufacturing (AM), AM vs Reverse Engineering, AM technology in Product Development, Tooling, Application of AM for Aerospace, Defense, Automobile, Bio-medical and General Engineering Industries

Unit-2 Design for AM (DFAM): Data Processing, CAD Model Preparation, Part Orientation and Support Structure Generation, Model Slicing, Tool Path Generation, DFAM for Part Quality Improvement, Customized Design and Fabrication for Medical Applications- Case Studies.

Unit-3 AM Technologies: Classification of AM Processes, Vat Photo-Polymerization Processes, Powder Bed Fusion Processes, Extrusion based Processes, Material Jetting based Processes, Binder Jetting Processes, Sheet Lamination Processes, Directed Energy Deposition Processes, Micro and Nano Additive Processes, Recent Development in AM Methods Guidelines for AM method selection, Challenges of Selection, Selection of AM technologies using Decision Methods.

Unit-4 Post Processing of AM Parts: Issues like accuracy, surface finish, build time, support structure, cost etc. Post processing of AM parts- Removal of Supports, Hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining Features, Interlocking Features, Reduction of Part Count in an Assembly, Identification of markings/ numbers etc. Surface Texture Improvement, Accuracy Improvement, Aesthetic improvement, Preparation for use as a Pattern, Property Enhancements using Non-Thermal and Thermal Techniques.

Unit-5 Materials Science for AM: Discussion on different Materials used, Use of Multiple Materials, Multifunctional and Graded Materials in AM, Role of Solidification Rate, Evolution of Non-Equilibrium Structure, Structure Property Relationship, New Materials Development, Monitoring and Control of AM defects.

Unit-6 Advances and Trends in Additive Manufacturing: 4D Printing, Bio-printing. Metal based Printing, Solid State Material Deposition, Hybrid Layered Manufacturing, Segmented Object Manufacturing, Rapid Tooling etc.

Text Books:

1. Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles & Applications", World Scientific, 2003.

2. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer.

3. A. K. Kamrani, E., A. Nasr, "Rapid Prototyping: Theory & Practice, Springer, 2006.

Reference Books:

1. Andreas Gebhardt and Jan-Steffen Hötter "Additive Manufacturing: 3D Printing for Prototyping and Manufacturing", Hanser publications, United States, 2015.

2. lan Gibson, David W. Rosen and Brent Stucker "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", 2nd edition, Springer., United States, 2015.

3. Patri K. Venuvinod, Weiyin Ma, "Rapid Prototyping: Laser-Based and Other Technologies, Springer, 2004,

4. Frank W. Liou, Rapid Prototyping and Engineering Applications: A Toolbox for Prototype Development, CRC Press, Taylor and Francis Group, 2007.

Course Outcomes (COs):

On completing this course students will be able to:

1. develop the basic concepts of AM and associated technologies to transform an idea into product development.

2. select and use correct CAD and AM formats in the manufacturing of a 3D printed part.

3. apply the operating principles of liquid, powder and solid based AM processes to select an appropriate technique and material to suit particular product requirements

4. select important AM process parameters to improve the quality of additively manufactured parts.

ME 439	Tribology	L T P C
	B. Tech (Mechanical Engg.) Seventh Semester	**3 0 0 3**
	(Department Elective II)	

Unit-1 Introduction: Historical background of Tribology and introduction to Friction, Wear and Lubrication, Tribological considerations.

Unit-2 Surfaces and measurements: Nature of surfaces and their contact, Physico-mechanical properties of surface layer, Surface texture, Geometrical properties of surfaces, method of studying surface, Surface roughness measuring techniques, Contact between solid surfaces: smooth and rough, Surface characterization tools.

Unit-3 Wear: Fundamentals of wear, Practical application of Wear, Types of wear, Mechanism of wear (adhesive wear, abrasive wear, erosive wear, corrosive/oxidative wear, fatigue wear), Factors affecting wear behaviour, Wear of Metals, Wear of Ceramics, Wear of Polymers, Measurement of wear and debris analysis, Wear test equipment

Unit-4 Friction: Fundamentals of friction, Requirements of friction, Measurement methods, Role of friction, Causes and remedy of friction, Laws of static friction, Laws of rolling friction, Adhesion, Adhesion theory, Deformation, Friction theories, Stick-slip, Friction of metals and non-metals.

Unit-5 Lubrication: Functions of lubricants, Properties and types of lubricants and their industrial uses, Solid lubricants and their functions, liquid lubricants, greases, Importance of additives in lubricant, Types of additives, Different lubrication regimes: Hydrodynamic, Elastohydrodynamic, Boundary and partial lubrication,

Stribeck curve, Film thickness.

Text Books:

1. Gwidon W. Stachowiak and Andrew W. Batchelor. Engineering Tribology, 4th Edition, 2014,

2. Ian Hutchings and Philip Shipway. Tribology: Friction and Wear of Engineering Materials, 2nd Edition, 2017.

3. Bharat Bhushan. Introduction to Tribology. Wiley, 2nd Edition, 2002.

4. Prasanta Sahoo. Engineering Tribology. Prentice Hall India Learning Private Limited, 2005.

5. Ramsay Gohar and Homer Rahnejat. Fundamentals of Tribology. Imperial College Press, 2nd Edition, 2012.

Reference Books:

1. B.J.Hamrock, S.R.Schmid, B.O. Jacobson. Fundamentals of Fluid Film Lubrication, 2nd Edition.

2. P. A. Dearnley. Introduction to Surface Engineering. Cambridge University Press.

3. A. D. Sarkar. Friction and Wear. Academic Press, 1980.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. analyse the surface characteristics for different materials.

2. identify different characterization tools for desired surfaces characteristics.

3. identify different wear types and mechanism, their causes, and remedial measures.

4. apply the concept of friction to select different friction surfaces for different applications.

5. select/develop the suitable lubricants for effective tribological performance in different lubrication regimes.

ME 481	Battery and Fuel Cell Technologies B. Tech (Mechanical Engg.) Seventh Semester (Open Elective–II)	L T P C 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

3 0 0 3

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

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 485 Introduction to Optimum Design L T P C

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

(Open Elective II)

Unit-1 Introduction: Need of optimum designs. Basic terminologies design variables, objective functions, constraints, and variable bounds. Different types of optimization problems - single variable, multivariable, linear, non-linear, real/integer/discrete, single-objective, and multi-objective. Problem formulation. Fundamental concepts: global/absolute optimum point, local/relative optimum point, inflection point, and convex programming problems.

Unit-2 **Single-variable unconstrained optimization:** Graphical method. Exact method based on necessary condition. Direct search methods bracketing the optimum point by exhaustive search method and bounding phase method, and refining the optimum point by interval halving method and golden section search method. Gradient-based methods- Newton-Raphson method, bisection method, and secant method.

Unit-3 **Multi-variable unconstrained optimization:** Fundamental concepts gradient vector and Hessian matrix. Exact method based on necessary condition. Direct search methods Simplex search method, Hooke-Jeeves pattern search method, and Powell's conjugate search method. Gradient-based methods Cauchy's

steepest decent method, Newton's method, and Marquardt's method.

Unit-4 **Non-linear programming problems:** Kuhn-Tucker comditions and sensitivity analysis. Transformation methods. Penalty function method and Method of multipliers (augmented Lagrangian method). Direct search methods - Variable elimination method, complex search method, and random search method. Gradient-based linearized methods - Taylor series expansion and unidirectional search, move limit method, Frank-Wolfe method, Cutting plane method, and Feasible direction method.

Unit-5 Multi-variable constrained optimization: Linear programming problems Graphical and Simplex method

Unit-6 Integer programming Methods: Penalty function method, cutting plane method, and branch-and-bound method.

TEXT/REFERENCE BOOKS:

1. Kalyanmoy Deb: Optimization for Engineering-Algorithms and Examples: Prentice-Hall of India Pvt. Ltd., New Delhi.

2. Ashok D. Belegundu and Tirupathi R Chandrupatla: Optimization: Concepts and Applications in Engineering: Pearson Education, New Delhi.

3. Christos H. Papadimitriou and Kenneth Steiglitz: Combinatorial Optimization: Algorithms and Complexity: Prentice-Hall of India Pvt. Ltd., New Delhi.

4. Conley. W: Computer Optimization Techniques: Pntrecelli Book, 1980

COURSE OUTCOMES:

1. Define and use optimization terminology and concepts, and understand how to classify an optimization problem.

2. Be able to model engineering minima/maxima problems as optimization problems.

3. Understand and apply unconstrained optimization theory for continuous problems, including the necessary and sufficient optimality conditions and algorithms such as: steepest descent, Newton's method, Conjugate gradient methods.

ME 486 Supply Chain Management L T P C

B. Tech - Mechanical Engineering – Open Elective 3 0 0 3

Unit 1

Introduction: Introduction to Distribution, Logistic and Supply Chain Management (SCM), Evolution of SCM, factors and key elements of SCM, Chain of communication of SCM, Understanding logistic and its role in supply chain, supply chain drivers and metrics, Value chain concept in supply chain, Fisher Framework and Hau Lee Framework, Supply chain strategies - Lean vs. Agile, Push Vs. Pull strategy in SCM, Hub and Spoke concept, Challenging and maintaining supply chain in India,

Unit 2

Logistic Management (LM): Logistics as part of SCM, Components of LM, Generic Value chain activities and Logistics Decisions, Logistics costs, different models, logistics sub-system – 3PL, 4PL, Inbound logistics Vs outbound logistics, Bullwhip effect in logistics, Distribution and warehousing management, Applications of Artificial Intelligence / Machine Learning in LM / SCM

Unit 3

Decision making for Supply chain: Basics of Decision making under Risk and Uncertainty, Types of problems, Secretary Problem, Optimal Strategy, Decision making for supply chain criteria and strategies, Payoff matrix and cost matrix, Laplace criterion, Criterion of Optimism, Criterion of Pessimism, Minimax Regret Criterion, Hurwicz Criterion, Probabilistic and Non-probabilistic approach (numerical on decision making in SC)

Unit 4

Purchasing and Vendor management: Basics of Purchasing and vendor management, Centralized and decentralized purchasing, Functions of purchase department, Procurement procedures, Negotiation, purchase policies, E-tendering, Use of mathematical model for vendor rating/ evaluation, Single vendor concept Vs. Multi-vendor concept, Management of stores, accounting for materials

Unit 5

Inventory Management: Concept, various costs associated with inventory, EOQ models and EPQ models, Buffer stock (trade-off between stock out / working capital cost), lead time reduction, re-order point / re-order level fixation, ABC, SDE, FNSD, HML, VED Analysis, Just-In-Time (JIT) and Kanban System of Inventory management, Numerical on inventory management

Unit 6

Demand forecasting in supply chain: Introduction to forecasting, the role of forecasting in the supply chain, qualitative and quantitative forecasting methods (numerical on demand forecasting), Transportation problems (Balanced and Unbalanced) in supply chain (numerical on transportation problem)

Unit 7

Recent Issues in SCM: Digital SCM, Role of Computer / IT in Supply Chain Management, the supply chain in IT framework, Customer Relationship Management (CRM), Internal Supply Chain Management (ISCM), Supplier Relationship Management (SRM), Transaction Management Foundation (TMF), Benchmarking - concept, features and implementation; Insourcing Vs Outsourcing, Value Addition in SCM - concept of demand chain management, supply chain integration, Case studies of supply chain management

Text Books / Reference Books:

1. Shah, J. (recent edition)- Supply Chain Management: Text and Cases; New Delhi

2. Sople. V.Vinod (recent edition)- Logistic Management- The Supply Chain Imperative

3. Raghuram G. (I.I.M.A.) - Logistics and Supply Chain Management (Macmillan, 1st Ed.)

4. Krishnan. Gopal - Material Management, (Pearson, New Delhi, 5th Ed.)

5. Agarwal D.K. - A Text Book of Logistics and Supply chain management (Macmillan, Ed.1)

6. Sahay B.S. - Supply Chain Management (Macmillan, 1st Ed.)

7. Chopra Sunil and Peter Meindl - Supply chain management (Pearson, 3rd Ed.)

Course Outcomes (CO):

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

1. Understand and comprehend fundamental role of supply chain management procedure in today's organizational environment

2. Understand and apply the current supply chain theories, practices and concepts utilizing case problems and problem-based learning situations

3. Develop the skills for designing the operational feasibilities of the supply chain with effective application capabilities to the real world business situation

4. Develop and utilize the skills such as planning, coordinating, negotiating, working effectively within uncertain diverse business environment, ethical decision making and use of technology

5. Demonstrate the use of effective communications skills, critical thinking, team building and presentation skills as applied to organizational problems

IC 401	**Entrepreneurship and Venture Development** **B. Tech (Mechanical Engg.) Seventh Semester** **(Open Elective–II)**	**L T P C** **3 0 0 3**

Unit-1 Introduction to Innovation and Entrepreneurial Idea Generation and Opportunity recognition; Entrepreneurship Fundamentals and Venture Structures; Factors influencing entrepreneurship; New generations of entrepreneurship viz. social entrepreneurship, Health entrepreneurship, Tourism entrepreneurship, Women entrepreneurship, Barriers to entrepreneurship.

Unit-2 Entrepreneurial Motivation, Stories of successful entrepreneur startup, Achievement theory, Design thinking for finding solutions, prototyping, idea evaluation, entrepreneurial outlook, value proposition design, questionier preparation and preparation, customer insight, ideas development, Values / Ethics, Risk-taking behaviour

Unit-3 Meaning, features & examples of Incubation, Startups, Industrial Park, Special Economic Zone, Micro, Small and Medium Enterprise (MSME), Khadi and Village Industries Commission (KVIC) and Applicability of Legislation. National Innovation and Startup Policy (NISP) 2019, Institute Innovtion and Starup Policy (IISP) 2020, Intellectual property Rights (IPR), Creative Commons (CC) License, Atmanirbhar Bharat, Make in India, Local for Vocal.

Unit-4 Preparation of Business model/Plan, Meaning and significance of a business plan, Guidelines for writing a business plan (BP), Components of an effective business model, core strategy, strategic resources, partnership network, and customer interface. Prerequisites from the perspective of an investor. Importance and diversity of a business model, potentially fatal flaws of business models.

Unit-5 Understanding Technology Readiness Level (TRL), Market Readiness Level (MRL), Innovation Readiness Level (IRL) stages and implications in innovative development, Financial plan, and Financial support from investors/ angel investors.

Unit-6 Introduction to Marketing Management, Concept of Needs, Wants, Demands, Profitability. Consumer Behaviour, Factors influencing

Consumer Behaviour, Marketing Research with respect to Product/Service, Feasibility Analysis, Industry & competition analysis, environment analysis, financial feasibility analysis.

Unit-7 Case Studies – one successful entrepreneur startup and one unsuccessful entrepreneur startup from your state, Critically analyse the cause of success/ failure considering all steps.

Text Books:

1. Khanka. S.S., "Entrepreneurial Development" S.Chand & Co. Ltd., Ram Nagar, New Delhi, 2013.
2. Hisrich R D, Peters M P, "Entrepreneurship" 8th Edition, Tata McGraw-Hill, 2013.
3. Rajeev Roy, "Entrepreneurship" 2nd Edition, Oxford University Press, 2011.
4. Osterwalder & Pigneur (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. John Wiley & Sons, Inc.

References Books:

1. Osterwalder & Pigneur (2014). Value Proposition Design: How to Create Products and Services Customers Want. John Wiley & Sons, Inc.
2. McClelland, D. C. (1958). Methods of measuring human motivation. In J. W. Atkinson (Ed.), Motives in fantasy, action, and society (pp. 7-42). Princeton, NJ: D. Van Nostrand Company, Inc.
3. Savita Mishra (2017) Motivation: A Key to Success, ISBN-978-1-387-10222-8, LULU publication Releigh NC 27607 United State.
4. Philip T. Kotler, Gary Armstrong, Prafulla Agnihotri (2018) Principles of Marketing 17th Ed. Pearson ISBN-10: 9789352865611, ASIN : **9352865618**
5. Donald F Kuratko, "Entrepreneurship – Theory, Process and Practice", 9th Edition, Cengage Learning, 2014.
6. Mathew J Manimala, "Entrepreneurship theory at crossroads: paradigms and praxis" 2nd Edition Dream tech, 2005.

Course outcomes (COs):

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

1. analyze the factor influences an entrepreneur startup
2. analyze the technical, finanacial and managerial aspects of entrepreneur startup
3. identify the steps for developing new products or services
4. develope successful business model for new or existing ventures

5. analyze critically all the steps to overcome the limitation for successful Technoprenurship.

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 **B. Tech (Mechanical Engg.) Eighth Semester** **(Deptt. Elective–III)**	L T P C 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 458	Design of Production Tooling	L T P C
	B. Tech (Mechanical Engg.) 8th Semester	3 0 0 3
	(Departmental Elective III)	

Unit-1 Work holding device: Purpose and function of work holder, Principles of jig and fixture design, Method of location, 3-2-1 Method of location, Principles of pin locations, Locating devices, Type of clamping devices, Jig bushes, Types of jigs, Classification of fixtures, Milling fixtures, Turning fixtures, Boring fixtures.

Unit-2 Press work dies design: Classification of presses, Classification of dies, Centre of pressure, Cutting action in die, Die clearances, Cutting forces in die, Stock stop pilots.

Unit-3 Knockout piercing die design, Blanking die design, Compound die design, Scrap-strip layout for blanking, Evolution of progressive die.

Unit-4 Drives in machine tools, Selection of range of spindle speeds, Setting upper limit and lower limit of centre lathe, Standard value of range ratio, Upper and lower limit of milling machines, Principle of stepped regulation.

Unit-5 Speed loss in G.P., Number of steps in the speed range, Number of practical subdivisions for obtaining a desired number of steps, Rules for the layout of gearboxes having sliding clusters, Types of structure, Ray diagrams, Decision making for the best ray diagram of a gearbox, Determining the number of teeth in gears, Strength of gear teeth, Determination of modules, Design of gearboxes, Mechanical step less drives

Text Books:

1. The textbook of Production Engineering, P.C. Sharma, S. Chand Publication

2. Jigs and Fixtures Design Manual, Prakash H. Joshi, Robert O. Paramly, Mc-Graw Hill

3. Principles of Machine Tools, Sen and Bhattacharya, Mc-Graw Hill

Reference Books:

1. Fundamentals of Tool Design, Anthony R., And Willis J. Potthoff Society of Manufacturing Engineers Konecny.

2. Tool Design, Donaldson, McGraw Hill.

Course Outcomes (COs):

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

1. To define the working holding devices for various machine tools

2. To identify the concepts of die design for various sheet metal operations

3. To evaluate the standard ranges and limits of machine parameters based on the machine drives.

4. To design the gearbox and mechanical drives for various machine tools and production systems.

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 **B. Tech (Mechanical Engg.) Eighth Semester** **(Open Elective–III)**	L T P C 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.

ME 496	Robotics and Robot Programming	L T P C
	B. Tech (Mechanical Engg.) 8th Semester	3 0 0 3
	(Open Elective II)	

Unit-1 Introduction to robots, Robot manipulators, Mobile robots, Robot anatomy Coordinate systems, Work envelope, Types and classification, Specifications Sensors, Actuators and drives. Different software tool introduction for the robot programming.

Unit-2 **Kinematics:** Representation of position and orientation of a rigid body, Homogeneous transformations, Forward and inverse kinematics problems, Denavit-Hartenberg (D-H) notations and parameters, Closed-form solutions Geometric and Numerical methods. Workspace analyses using different software tool and the programming instructions. Different industrial robots introduction and their application.

Unit-3 **Jacobian:** Linear and angular velocity of links, Velocity propagation, Jacobians for robotic manipulators, Statics and force transformation of robotic manipulators, Singularity analysis. Singular free workspace analyses and identification of the singularity using robotic manipulator programming.

Unit-4 **Dynamics:** Forward and inverse dynamics, Mass and inertia of links, Lagrangian formulation for equations of motion for robotic manipulators, Newton-Euler formulation method, Dynamic modelling. State space representation of dynamic equations of robotic manipulators. Joint torque/forces analyses through serial robotic programming tool.

Unit-5 **Trajectory:** Joint and Cartesian space trajectory planning and generation, Classical control concepts using the example of control of a single link, Independent joint PID control, Control of a multi-link manipulator, Nonlinear model based control schemes, Case studies of the dynamic analyses of the current robotic manipulators using software. Time trajectory analyses through programming using different robotic software tool. Application of the different industrial robot and their path planning demonstration.

Text Books:

1. John J. Craig, "Introduction to Robotics", 3rd Edition, Pearson Education, 2004.

2. Saha, S.K., "Introduction to Robotics", 2nd Edition, McGraw-Hill Higher Education, New Delhi, 2014.

3. Ashitava Ghosal, "Robotics: Fundamental Concepts and Analysis", Oxford, New Delhi, 2006.

4. Mikell.P.Groover, Mitchell Weiss, Roger. N. Nagel, Nicholas. G. Odrey, "Industrial

Robotics-Technology, Programming and Applications", Tata McGraw-Hill Publishing Company Limited, New Delhi, Third Reprint 2008.

5. Deb, S. R., and Sankha Deb. 2010. Robotics Technology and Flexible Automation. 2nd ed. New York: McGraw-Hill Education.

Reference Books:

1. Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo. Robotics. Springer-Verlag London 2009.

2. Miomir Vukobratovic, Milan Djurovic, Dragan Hristic, Introduction to Robotics, Springer.

3. Peter Corke, Robotics, Vision and Control, Springer Cham.

Course Outcomes (COs):

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

1. Develop the relationship between mechanical structures of industrial robots and their operational workspace characteristics.

2. Develop a relationship between the gripper to the base of the robotic system using kinematics relation.

3. Formulate and develop the mapping of the frames of the robotic manipulator and analyse the speed of the robotic system using the fundamental knowledge of the Jacobian matrix and singularities.

4. Formulate and develop the dynamic behaviour of the robotic manipulators in the real time situation of the robot with the fundamental concept of joint trajectory generation and motion planning.

5. Develop the robot control scheme in the real time application and to control the robotic manipulators. Create the simple and complex path for the robotic manipulators and will able to perform the usage of different control algorithm.

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