Department of Mechanical Engineering

College of Technology and Engineering, Udaipur

PROPOSED FROM
2019-2020

COURSE DESCRIPTION

B. TECH. (Mechanical Engineering)

Vision

To provide mechanical engineers of highest calibre who would engage in research, design and development to help building the nation towards self-reliance in her technological need and to become a centre of excellence in education, research and technological service to the nation for its need in design and manufacturing independence.

Mission

- To promote academic growth in the discipline of mechanical engineering by offering state-of-the-art undergraduate, postgraduate and doctoral programmes.
- To arm the graduates with latest technologies and knowledge of applying them for finding technically feasible and economically viable solutions of the problems of manufacturing sector and to make them globally competitive.
- To create an ambience of academic excellence in which new ideas, research and entrepreneurship flourish and from which the leaders and innovators of tomorrow emerge.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO 1: To prepare students for successful careers in industry that meet the needs of Indian and multinational companies

- *PEO 1.1.* Placement
- *PEO 1.2.* Progress in professional career

PEO 2: To develop the ability among students to synthesize data and technical concepts for application to product design

- *PEO 2.1. Analyse real life problem*
- *PEO2.2.* Design and develop economically feasible and socially acceptable Computing *Solutions*

PEO 3: To provide opportunity for students to work as part of teams on multidisciplinary projects.

- *PEO 3.1.* Professional conduct
- *PEO 3.2.* Interpersonal skills

PEO 4: To provide students with a sound foundation in the mathematical, scientific and engineering fundamentals necessary to formulate, solve and analyze engineering problems and to prepare them for graduate studies

- *PEO 4.1.*Research
- *PEO 4.2.* Higher education

PEO 5: To promote student awareness of the life-long learning and to introduce them to professional ethics and codes of professional practice

- *PEO 5.1.* Adapting to current trends in technology
- *PEO 5.2.* Socially responsible and ethical practices

Programme Outcomes (POs)

1. Graduates will demonstrate basic knowledge in mathematics, science and engineering.
2. Graduates will demonstrate the ability to design and conduct experiments, interpret and analyze data, and report results.
3. Graduates will demonstrate the ability to design a mechanical system or a thermal system or a process that meets desired specifications and requirements.
4. Graduates will demonstrate the ability to function on engineering and science laboratory teams, as well as on multidisciplinary design teams.
5. Graduates will demonstrate the ability to identify, formulate and solve mechanical engineering problems.
6. Graduates will demonstrate an understanding of their professional and ethical responsibilities.
7. Graduates will be able to communicate effectively in both verbal and written forms.
8. Graduates will have the confidence to apply engineering solutions in global and societal contexts.
9. Graduates should be capable of self-education and clearly understand the value of lifelong learning.
10. Graduates will be broadly educated and will have an understanding of the impact of engineering on society and demonstrate awareness of contemporary issues.
11. Graduates will be familiar with modern engineering software tools and equipment to analyze mechanical engineering problems.

First Year B. Tech. – I Semester

ME112 (ESC) MECHANICAL ENGINEERING

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Apply the principles of conservation of mass, first and second laws of thermodynamics to analyse closed steady state systems and processes involving heat and work interactions.
CO2: Show understanding of concepts of reversibility, entropy and Carnot cycle.
CO3 Demonstrate knowledge of properties of steam and ability to compute them from steam tables and Mollier chart.
CO4: Understand construction and working of steam boilers, steam engines and their specific applications.
CO5: Compute efficiency, power output, etc. of various vapour and gas cycles.
CO6: Demonstrate knowledge about construction and working of IC engines.

Unit 1

Thermodynamics: Thermodynamic properties, closed and open systems, flow and non-flow processes, gas laws, laws of thermodynamics, internal energy. Application of First Law in heating and expansion of gases in non-flow processes only.

Second law of thermodynamics: Kelvin-Planck and Claussius statements. Reversible processes, Carnot cycle, Carnot theorem. Reversed Carnot cycle. Entropy, physical concept of entropy.

Unit 2

Properties of Steam: Difference between gas and vapour, change of phase during constant pressure process. Generation of Steam, triple point and critical point. Internal energy and entropy of steam. Use of steam tables and Mollier chart, heating and expansion of vapour in non-flow processes.

Unit 3

Vapour Power Cycles: Introduction to Carnot Cycle, Rankine cycle and modified Rankine cycle.

Steam Generators: Classification of steam boilers. Cochran, Lancashire, Locomotive and Babcock-Wilcox boilers, Boiler mountings and accessories.

Steam Engines: Introduction to simple and compound steam engines.

Unit 4

Gas Power Cycles: Introduction. Air Standard efficiency, other engine efficiencies and terms. Otto, diesel and dual cycles. Calculation of efficiency, mean effective pressure and their comparison.

Internal Combustion Engines: Introduction, Classification, terminology and description of IC Engines. Four stroke and two stroke petrol, gas and diesel engines. Comparison of petrol and diesel engines. Simple carburettor.

Text Books/References:

1. M. L. Mathur and F. S. Mehta: Thermal Engineering, (Vol. I, SI Edition), Jain Brothers, New Delhi.
2. R. K. Purohit: Foundation of Mechanical Engineering, Scientific Pub. (India), Jodhpur.
3. P.K. Nag: Engineering Thermodynamics, TMH.

ME113 (ESC) WORKSHOP PRACTICE

	L	T	P
Credit	0	0	1.5
Hours	0	0	3

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Demonstrate knowledge of characteristics of various types of woods used in engineering applications.
CO2: Demonstrate knowledge of tools and operations in carpentry work, black smithy, fitting, sheet metal and plumbing works in engineering practice.
CO3 Identify and use measuring instruments in workshop practice and pipe fittings.

CO4: Learn use of tools in the carpentry, fitting, smithy, sheet metal and plumbing shop to make simple jobs.

Carpentry Shop: Acquaintance with types of wood, tools and their uses. Simple exercises involving basic operations like sawing, planning, chiselling, etc. Preparation of simple joints, cross half lap joint, dovetail joint, bridle joint, tenon and mortise joint.

Smithy Shop: Acquaintance with types of tools and their uses. Simple exercises involving basic operations like bending, drawing, punching, shaping, upsetting, and riveting.

Fitting Shop: Acquaintance with tools, measuring and marking tools, precision measuring tools and their uses. Simple exercises involving basic operations like sawing, chipping, filling, drilling, reaming, threading with taps and dies.

Sheet Metal and Plumbing Shop: Demonstration of basic tools, pipe fittings and operations.

Texts books/References:

1. S.K. Hajra Choudhury and A.K. Hajra Choudhury: Elements of Workshop Technology (Vol. I), Media promoters & Publishers Pvt. Ltd., Bombay.

First Year B. Tech. – II Semester

ME123 (ESC) MECHANICAL DRAWING

	L	T	P
Credit	0	0	1
Hours	0	0	2

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Demonstrate knowledge of conventional representation employed in machine drawing.
CO2: Make detailed drawings of simple machine parts in first/third angle projection by proper choice of sectioned views as per need.
CO3 Read, interpret and visualize machine parts from a given drawing.
CO4: Demonstrate knowledge of riveted, welded, threaded and screwed joints and fastenings.

Introduction, conventional representation of different materials used in machine drawing, Introduction to BIS codes.

Orthographic Projection: First and third angle methods of projection. Preparation of working drawing from models and isometric views. Drawing of missing views.

Dimensioning: Different methods of dimensioning.

Sectional Views: Concept of sectioning. Revolved and oblique section. Sectional drawing of simple machine parts

Riveted and Welded Joints: Types of rivet heads and riveted joints. Processes for producing leak proof joints. Symbols for different types of welded joints.

Screw Fastenings: Nomenclature, thread profiles, multistart threads, left and right hand threads. Square headed and hexagonal nuts and bolts. Conventional representation of threads. Different types of lock nuts, studs, machine screws, cap screws and wood screws. Foundation bolts.

Different types of joints: Knuckle joint, cotter joint and universal joint.

Text Books/References:

1. N. D. Bhatt. Machine Drawing, Charotar Book Stall, Anand.
2. V. Laxminarayan and ML Mathur. A Text Book of Machine Drawing, Jain Brothers, New Delhi.
3. P. S. Gill. Machine Drawing, S. K. Kataria & Sons, New Delhi.

ME124 (ESC) WORKSHOP TECHNOLOGY

	L	T	P
Credit	2	0	1
Hours	2	0	2

Course Outcomes:	**Upon completion of this course the students will be able to:**
CO1:	Understand welding principles, equipment and tools of arc-, gas and resistance welding, brazing and soldering.
CO2:	Describe construction, operations and tools of lathe, shaper and drilling machines.
CO3	Understand basic hot and cold forming operations.
CO4:	Demonstrate knowledge of types of patterns, cores, moulding sands and tools.
CO5:	Understand sand, permanent mould and investments castings and casting defects.

Unit 1

Welding: Introduction to types of welding. Principle of electric arc welding, welding tools and safety devices, welding positions, welding joints, types of welds, Resistance welding. Oxyacetylene gas welding, types of flames. Soldering and Brazing.

Unit 2

Lathes: Constructional details of centre lathe. Main operations and tools used on centre lathes.

Shaper: Types of shapers. Constructional details of standard shaper, shaper tools and main operations.

Unit 3

Drilling Machines: Types of drilling machines. Constructional details of pillar type and radial drilling machines. Main operations. Twist drills, drill angles and sizes.

Forming: Basic descriptions and applications of hot and cold working processes, forging, bending, shearing, drawing and forming operations.

Measurement and Inspection: Classification of measuring instruments, linear and angular measurement, comparators.

Unit 4

Foundry & Casting Practices: Introduction, types of patterns, Mouldings, moulding materials, cores, moulding tools and equipments. Moulding sands, properties of moulding sands. Casting defects. Casting methods: Permanent mould casting, investment casting.

Practicals:

Practical exercises on welding, pattern making, foundry and machining operations.

Text Books/References:

1. Mathur Mehta and Tiwari: Elements of Mechanical Engineering, Jain Brothers, New Delhi.
2. S.K. Hajra Choudhury and A.K. Hajra Choudhury: Elements of Workshop Technology (Vol. I and II), Media promoters & Publishers Pvt. Ltd., Bombay.

Second Year B. Tech. (Mech. Engg.) – III Semester

BS231 (BSC) MATHEMATICS-III

	L	T	P
Credit	2	1	0
Hours	2	1	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Understand finite differences and interpolation.
CO2: Apply numerical differentiation and integration to engineering problems.
CO3 Numerically solve ordinary differential equations occurring in various engineering fields.
CO4: Apply Laplace Transform to solve differential equations.

Unit 1

Interpolation: Finite differences, various difference operators and their relationships, factorial notation. Interpolation with equal intervals; Newton's forward and backward interpolation formulae, Lagrange's interpolation formula for unequal intervals.

Unit 2

Gauss forward and backward interpolation formulae, Stirling's and Bessel's central difference interpolation formulae.

Numerical Differentiation: Numerical differentiation based on Newton's forward and backward, Gauss forward and backward interpolation formulae.

Unit 3

Numerical integration: Numerical integration by Trapezoidal and Simpson's rule.

Numerical Solutions of Ordinary Differential Equations: Picard's method, Taylor's series method, Euler's method, modified Euler's method, Runge-Kutta methods.

Unit 4

Laplace Transform: Laplace transforms of elementary functions; Basic properties of Laplace transform; Initial value theorem, final value theorem and convolution property of Laplace transform; Inverse Laplace transforms. Applications of Laplace transform to solve ordinary differential equations

Text Books/References:

1. H.C. Saxena: Text Book of Finite Differences and Numerical Analysis, S. Chand and Co.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain: Numerical Methods for Scientific and Engineering computation, New Age International (P) Ltd.
3. N.P. Bali and Manish Goyal: A Text book of Engineering Mathematics, Laxmi Publication Pvt. Ltd., New Delhi (VII Edition).
4. S.P. Goyal and A.K. Goyal: Integral Transforms, Jaipur Publishing House, Jaipur.

ME231 (PCC) MECHANICS OF SOLIDS-I

	L	T	P
Credit	3	1	1
Hours	3	1	2

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Demonstrate a knowledge of basic concepts, elastic behaviour under loading, elastic moduli and strain energy.
CO2: Compute stresses due to rotation and in thin and thick cylindrical and spherical shells.
CO3 Analyse complex plane stress/strain problems to determine stress/strain components and principal stresses/strains at a point.
CO4: Analyse the components under flexural and torsional (circular cross section only) loading.
CO5: Compute the critical or buckling load in columns.

Unit 1

Fundamentals: Stress and strain, engineering stress and strain, true stress and strain. Saint-Venant's principle. Stress-strain diagrams, mechanical properties of materials, elasticity and plasticity. Shear stress and strain, pure shear, complementary shear. Linear elasticity and Hooke's law. Poisson's ratio, volumetric strain, bulk modulus of elasticity. Elastic constants and relation between elastic moduli. Stress and strain in axially loaded members. Temperature and prestrain effects, statically indeterminate problems. Composite bars. Dynamic loading. Strain energy.

Unit 2

Analysis of Stress and Strain: Stress at a point, stress components, stresses on inclined planes. Plane stress and strain. Mohr's circle representation of plane stress and strain. Principal stresses and strains, maximum shear stresses. Hooke's law for plane stress, strain energy for plane stress. Application to components under combined loading, thin spherical and cylindrical shells, shafts under bending. Triaxial and spherical state of stress. Generalised Hooke's law.

Stresses in thin cylindrical and spherical shells subjected to internal and external pressures. Thick cylinders, compound cylinders, stresses due to rotation.

Unit 3

Beams under Flexural Loads: Bending moment and shear force, relation between load, shear force, and bending moment. Bending moment and shear force diagrams for simply supported, cantilever, fixed and overhang beams under static loading of different types viz. point loads, uniformly distributed loads, linearly varying loads, and couples. Pure bending. Theory of simple bending of initially straight beams. Flexural stresses in beams. Built up and composite beams. Shear stresses in beams of rectangular, circular and I-section. Shear formula, effect of shear strain. Bending of curved bars.

Unit 4

Torsion: Torsion of solid and hollow circular shafts. Non-uniform torsion. Statically indeterminate torsional members. Torsion in composite shafts and thin walled tubes. Combined bending and torsion, effect of end thrust. Keys and couplings.

Columns: Buckling and stability, critical load. Euler's theory for initially straight column with different end conditions, equivalent length, limitation of Euler's formula. Rankine's formula. Columns under eccentric loading. Secant, Perry's and Indian Standard formulae.

Practicals:

Tension test on UTM and determining mechanical properties. Compression test. Charpy test. Izod test. Hardness testing. Performance of torsion test, bending test.

Text Books/References:

1. James M. Gere and Stephen P. Timoshenko:Mechanics of Materials (2^{nd} ed.), CBS Publishers & Distributors,Delhi.
2. B. C. Punmia. Strength of Material and Mechanics of Structures (Vol. I),8^{th} edition, Standard Publishers & Distributors. Delhi.
3. S. H. Crandall, N. C. Dahl and S.J. Lardner. An Introduction to Mechanics of Solids, TMH.
4. E.P. Popov. Introduction to Mechanics of Solids, Prentice Hall.
5. B.C. Punamia, Ashok Kumar Jain, Arun Kumar Jain, Mechanics of Material, 2016. Laxmi Publication (P) Ltd., New Delhi

ME232 (HSM) INDUSTRIAL MANAGEMENT

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Demonstrate knowledge of history, principles and functions of business organisations.
CO2: Discuss principles, elements and functions of management.
CO3 Summarise contributions of Taylor, Gilberth, Mayo and Kurt Lewin to development of scientific management.
CO4: Understand concepts related to personnel management.
CO5: Compute merit rating and wage payments as per different schemes.

CO6: Understand industrial relations concepts and labour legislations in India.
CO7: Understand elements of cost and depreciation.

Unit 1

Introduction: Historical development, functional areas of business and the need for integrating these through the development of business goals

Organisation: Meaning of organisation, administration and management. Ownership. Forms of business organisation, sole proprietorship, partnership, joint stock companies, cooperative societies, public enterprises.

Principles of organisation, types of organisation structures. Forms of organisation, line, functional, line and staff and committee. Authority and responsibility, delegation of authority, span of control. Organisation charts.

Unit 2

Management: Principles and elements of management. Functions of management, planning, organisation, staffing, directing, coordination and control. Types and levels of management, management structure. Scientific management, development of management thought with reference to the work of Taylor, Gilberth, Mayo and Kurt Lewin.

Unit 3

Personnel Management: Objectives, organisation, functions and responsibilities of personnel management, relationship with other departments. Brief idea about motivation, morale, perception, leadership attitudes, frustration, fatigue, accidents, values, opinion.

Man power Planning, recruitment, selection, job specification and job qualification. Training and placement.

Wage payment System: Job evaluation, merit rating, methods of wage payment, time wages, piece wage system and incentive schemes.

Industrial Relations and Labour legislation: Management union relations, trade union movement, collective bargaining, employees participation in management. Brief ideas about various labour acts.

Unit 4

Elements of costing and Financial statements: Classification of costs, direct and indirect cost, labour, material and over-head, Prime cost, factory cost, fixed cost, variable cost, increment cost, Allocation of overhead costs. Analysis of Break even chart. Depreciation of plant, building and facilities. Method of computing depreciation.

Text Books/References:

1. Banga and Sharma: Engineering Economics and Industrial Organisation. Khanna Publishers, New Delhi.
2. Kumar Surendra: Personnel Management and Industrial Relations. Satya Prakashan, New Delhi.
3. S. Eilon: Elements of Production Planning and Control, Universal Book Corporation, Bombay.
4. R Lal: Essentials of Industrial Management. Bhatia Bhawan, Patna.
5. Philippo: Principles of Personnel Management, McGraw Hill.

M. Mahajan. Industrial Engineering and Production Management, Dhanpat Rai & Sons, Delhi.

ME233 (PCC) MANUFACTURING PROCESS- I

	L	T	P
Credit	3	0	1
Hours	3	0	2

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Demonstrate knowledge of patterns, moulding processes & materials and foundry equipment including furnaces.
CO2: Design pattern, core prints and gating system for sand metal casting processes.
CO3 Show understanding of the principles, equipment and features of permanent moulding processes.
CO4: Understand the principles, equipment and characteristics of conventional and advanced welding/joining processes.
CO5: Demonstrate knowledge of casting and welding -defects, inspection and testing.
CO6: Demonstrate knowledge of powder metallurgy, screw threads and gears.

Unit 1

Foundry: Classification of casting processes. Patterns- types, materials, allow¬ances and colour coding for patterns. Core materials, core prints, types of cores and core boxes.

Moulding materials. Types, properties, testing of moulding sands, sand additives. Sand moulding processes. Special moulding processes.

Foundry Mechanisation: Moulding and core making machines, patterns for machine moulding and material handling systems. Cupola furnace, electric arc and induction furnaces.

Unit 2

Solidification of casting, Gating and risering systems, types of gates and risers. Use of padding, chills, exothermic and insulating sleeves.

Principle of casting design. Cleaning, finishing, defects and inspection of casting.

Other Casting Processes: Permanent mould casting, investment casting, centrifugal and semi-centrifugal casting, centrifuging, continuous casting, die casting and die casting machines.

Unit 3

Welding: Classification of welding processes, metallurgy of weld. Oxyacetylene gas welding & cutting of metals. Principle of arc welding, Welding machines and tools, arc characteristics and control. Welding electrodes, classification and applications. Carbon arc, Metal inert gas (MIG), Tungsten inert gas (TIG), Atomic hydrogen, Plasma, Submerged arc, flux-cored and electro slag welding.

Other welding and related methods: Resistance welding. Thermal spraying, Thermit welding, Pressure welding, Solid state welding methods. Welding defects and remedies. Destructive and non-destructive testing methods for welded joints.

Newer welding methods: Electron beam welding, Laser beam welding.

Unit 4

Powder Metallurgy: Introduction, production of powder, manufacturing of parts by powder metallurgy and their applications.

Moulding and extrusion of plastic, forming and drawing of plastic sheets.

Production of screw threads, rolling, milling and uses of dies. Production of gears by milling, shaping, and hobbing, Finishing of gears.

Practicals:

Pattern making, moulding and casting exercises involving cores and considering allowances. Study of cupola and induction furnaces. Experiments on foundry sand testing like moisture, green strength, etc.

Exercises/demonstration on advanced metal arc (TIG, MIG, etc.), oxyacetylene welding and cutting, resistance welding and metal spraying.

Text Books/References:

1. S.K. Hajra Choudhury and A.K. Hajra Choudhury: Elements of Workshop Technology, Vol. I, Media Promoters & Publishers Pvt. Ltd., Bombay.
2. JS Campbell: Principles of Manufacturing Materials and Processes, TMH.
3. Richard L. Little: Welding and Welding Technology, TMH Co. Ltd., New Delhi.
4. R. K. Purohit: Mechanical Engineering, Scientific Publishers, Jodhpur

ME234(PCC) KINEMATICS OF MACHINES

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Apply the principles of kinematic mechanisms to determine mobility and inversions of common mechanisms.
CO2: Analyse simple planar mechanisms for position, velocity and acceleration using graphical methods and algebraic methods.
CO3 Understand vector method of analysis using loop closure equations.
CO4: Synthesise simple four bar mechanisms for function generation using Freudestein's method.
CO5: Design a layout of cam for specified motion.
CO6: Determine kinematic parameters for different types of involute gears and gear trains.

CO7: Apply laws of mechanics to solve problems in belt, rope, chain, brakes and dynamometers.

Unit 1

Mechanisms: Kinematic pairs, kinematic chains, and mechanisms, limits and disguise of pairs, equivalent linkages. Mobility, Grübler's and Kutzbach's criteria. Four bar chain, slider crank chain, and double slider crank chain and their inversions. Various mechanisms viz. Pantograph, straight line mechanisms, steering mechanisms, Hooke's joint, Geneva mechanism.

Kinematic Analysis of Plane Mechanisms: Instantaneous centres, Aronhold-Kennedy's theorem, angular velocity ratio theorem, velocity analysis using instant centres. Velocity and acceleration using graphical method, Coriolis component of acceleration. Algebraic method for velocity and acceleration analysis of four bar chain and slider crank chain.

Introductory concepts of complex algebra and vectorial methods of analysis, loop closure equation and numerical solutions using computers (No numerical problems).

Unit 2

Kinematic Synthesis of Planar Mechanisms: Steps and classes of synthesis. Dimensional synthesis, precision points, structural error, Chebychev spacing. Freudestein's methods of synthesis and application to simple function generation problems for four-bar chain.

Cams: Classification of cams and followers. Radial cam nomenclature. Analysis of basic follower motions viz. uniform velocity, simple harmonic, uniform acceleration and retardation, and cycloidal motions. Synthesis of cam profile using graphical approach for roller, flat faced, and knife edged followers. Analysis of follower motion for tangent came with roller follower and circular arc cam with flat faced follower.

Unit 3

Gear: Law of gearing, velocity of sliding between teeth in mesh. Involute and cycloidal profile for gear teeth and their characteristics. Interchangeable gears, tooth systems. Spur gears, spur rack, arc and path of contact, contact ratio. Interference and undercutting, minimum number of teeth to avoid interference. Parallel axis helical gears. Tooth proportions, equivalent spur gear. Herringbone gears. Crossed axis helical (spiral) gears, velocity ratio and efficiency. Straight bevel gears, tooth proportions, velocity ratio, equivalent spur gear, other types of bevel gears. Worm and worm gear, nomenclature, velocity ratio and efficiency.

Gear Trains: Simple, compound, reverted, and epicyclic trains. Gear train applications, gear boxes and differentials. Determining velocity ratio by numerical and tabular methods.

Unit 4

Drives with Flexible Connectors: Types of belts and belt drives, Slip and creep. Centrifugal tension, condition for maximum power, initial tension. V belt and rope drives. Chain drives, types of power transmission chains, velocity ratio.

Brakes and Dynamometers: Block brake, band brake, band and block brake. Braking action, Braking system of automobiles. Absorption and transmission type dynamometers.

Text Books/References:

1. P. L. Ballaney: Theory of Machines, Khanna Publishers, Delhi.
2. Joseph E. Shigley and John J. Uicker, Jr.: Theory of Machines and Mechanisms (International Edition), McGraw Hill Inc.
3. R. S. Khurmi and J. K. Gupta: Theory of Machines, Eurasia Publishing House (Pvt.) Ltd., New Delhi.
4. H. H. Mabie and C. F. Reinholtz: Mechanisms and Dynamics of Machinery. John Wiley & Sons.

ME235 (ESC) MACHINE DRAWING

	L	T	P
Credit	0	0	1
Hours	0	0	2

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Demonstrate knowledge of different types of valves and bearings.
CO2: Demonstrate knowledge of various drawing conventions and symbols as per the prevalent standards codes.
CO3 Prepare and interpret assembly and production drawings.
CO4: Draw and interpret piping drawings.

Pipes and Pipe joints: Standard conventional symbols for pipe joints and fittings, piping diagrams.

Bearing: Ball, roller, and needle bearings.

Valves: Stop, gate, globe, check, butterfly and needle type valves, safety valves.

Limits, fits, tolerances, conventional symbols, surface finish, etc. Familiarisation with various BIS and other codes currently in vogue.

Preparation of assembly and production drawings indicating tolerances, surface finish, etc. in detail of simple machine components and assemblies like couplings, clutches, gear assemblies, tool post, reciprocating engine components, viz. piston, connecting rod, cross head, etc.

Text Books/References:

1. N. D. Bhatt: Machine Drawing, Charotar Book Stall, Anand.
2. V. Laxminarayan and ML Mathur: A Text Book of Machine Drawing, Jain Brothers, New Delhi.
3. P. S. Gill: Machine Drawing: S. K. Kataria & Sons, New Delhi.

ME236(ESC) MATERIALS SCIENCE

	L	T	P
Credit	2	0	0
Hours	2	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Demonstrate knowledge of engineering materials and their suitability for different applications.
CO2: Describe the structure of crystalline materials using Bravais Lattices and Miller Indices.
CO3 Explain the effects of crystal imperfections on material properties.
CO4: Explain deformation and strengthening mechanisms in materials and creep, fatigue and fracture using theories of materials science.
CO5: Describe the various forms of carbon-iron alloys using binary phase diagrams.
CO6: Demonstrate knowledge of various heat treatment processes and their characteristics for steels and cast irons.

Unit 1

Engineering Materials: Effects of alloying elements in steel. Low alloy steels, stainless steel, magnetic steels, tool steels, materials for high and low temperature service. Brasses and Bronzes. Aluminium base alloys. Bearing Materials. Engineering Plastics.

Crystalline Nature of solids: Crystal structure, space lattice and constants, Miller indices, allotropy. Imperfection in crystals, point and line defects, grain boundary and its effect on properties.

Unit 2

Plastic Deformation of Metals: Mechanism of plastic deformation, role of dislocation, slip and twining. Work hardening, theories of recrystallisation and grain growth. Elementary treatment of creep, fatigue and fracture. Methods of studying macro and microstructure.

Unit 3

Phase Transformation in Alloys: Mechanism of solidification in pure metals, free energy, critical size of nucleus. General principles of phase transformation in alloys, phase rule and equilibrium diagrams, relationship with structure and properties. Equilibrium diagrams of common binary systems. Equilibrium diagram of iron-carbon alloys, allotropic forms of iron and various forms of carbon in iron-carbon alloys.

Unit 4

Heat Treatment of Steels and Cast Irons: Phase transformations in steel, S-curves, ageing. Detailed study of various heat treatment processes- hardening, tempering, annealing, precipitation, and surface hardening. Chemical heat treatment of steel, carburising and nitriding. Hardenability. Heat treatment of cast irons. Heat treatment furnaces.

Text Books/References:

1. V. Raghvan, Physical Metallurgy: Principles and Practice, PHI.
2. Rajan et al., Heat Transfer: Principles and Technology, PHI.
3. Y. Lakhtin, Engineering Physical Metallurgy, MIR Publishers.

EE236 (ESC) ELECTRICAL TECHNOLOGY

	L	T	P
Credit	2	0	1

Hours	2	0	2

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Understand principles of operations and performance characteristics of DC machines.
CO2: Determine regulation efficiency of transformers.
CO3 Understand operating principle and performance characteristics of alternators.
CO4: Understand principles of operations and performance characteristics of induction and synchronous motors.

Unit-1

DC Machines: Characteristics curves of DC generators and motors, application of motors for different uses, starting and speed control of motors.

Unit-2

Transformers: Phasor diagram and equivalent circuits, regulation efficiency and their determination. Open circuit, short circuit and Sumpner's test.

Unit-3

Induction Motors: Polyphase induction motors – starters, equivalent circuit, effect of rotor resistance, torque-slip curves, speed control by rotor resistance, pole changing and cascading, use in industry. Single phase induction motor – starting methods.

Unit-4

Alternators: Elementary idea of armature winding. Calculation of induced EMF, factors affecting generating EMF Open circuit, short circuit and load characteristics. Voltage regulation and its determination by synchronous impedance methods. Synchronising.

Synchronous Motors: Methods of starting. Power angle characteristics of cylindrical rotor machine, operation of synchronous motor as a condenser and as a reactor. Applications in industries.

Practicals:

Lab practicals will be as per the theory syllabus.

Text Books/References:

1. Nagrath and Kothari: Electrical Machines, Tata McGraw-Hill Publishing Company Ltd, New Delhi.
2. Ashfaq Hussain: Fundamentals of Electrical Engineering,

Second Year B. Tech. (Mech. Engg.) – IV Semester

BS241 (BSC) MATHEMATICS-IV

	L	T	P
Credit	2	1	0
Hours	2	1	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Apply Fourier series and harmonic analysis to engineering problems.
CO2: Solve nonlinear equations by numerical methods.
CO3 Solve partial differential equations with constant coefficients.
CO4: Apply probability distributions, correlation and regression analysisto engineering problems.

Unit-1

Fourier Series: Fourier series, even and odd functions; Half range series; Change of interval; Exponential form of Fourier series; Harmonic analysis.

Unit-2

Roots of Nonlinear (Algebraic and Transcendental) Equations: Bisection method, False position method, Newton Raphson method; Convergence of False position and Newton Raphson method. Complex roots of polynomials by Bairstow's method.

Unit-3

Partial Differential Equations: Classification of partial differential equations; Method of separation of variables to solve Heat equation, Wave equation and Laplace's equations.

Unit-4

Statistics: Correlation and regression; Principle of least square method and curve fitting.

Probability Distribution Functions: Random variable; Mathematical expectations; Moment generating functions; Discrete and continuous distribution functions; Binomial, Poisson and Normal distributions.

Text Books/References:

1. J.L. Bansal and H.S. Dhami: Differential Equations (Vols.-II), Jaipur Publishing House, Jaipur (2005).
2. N.P. Bali and Manish Goyal: A Text book of Engineering Mathematics (VII Edition), Laxmi Publication Pvt. Ltd., New Delhi.
3. R.K. Jain and S.R.K. Iyengar: Advanced Engineering Mathematics (II Edition), Narosa Publishing House, New Delhi.
4. S.C. Gupta and V.K. Kapoor: Mathematical Statistics, Sultan Chand & Sons, New Delhi.

ME241(PCC) MECHANICS OF SOLIDS-II

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Formulate and solve mathematical models to determine the deflection of beams.
CO2: Analyse springs for stresses and displacements.
CO3 Apply various theories of failure for predicting safety/failure of components under complex loading.
CO4: Determine the deflection of simple structural members from energy methods.

Unit 1

Deflection of Beams: Differential equations of deflection curve, sign convention. Moment curvature relation. Transverse deflection of beams under static loading. successive integration methods, superposition method, area-moment method, methods using discontinuity functions. Deflection of simple non prismatic beams. Strain energy in bending.

Unit 2

Deflection of Statically Indeterminate Beams: Statical indeterminacy. Superposition, moment-area and successive integration methods. Continuous beams, use of three-moment equations.

Springs: Close coiled helical spring subject to axial load and couple. Open coiled helical spring subjected to axial pull and torque. Springs in series and parallel. Thin flat spiral spring. Leaf springs, quarter elliptical springs. Stresses and defections in leaf springs.

Unit 3

Members Subjected to Combined Loads: Short struts subjected to eccentric loads, shafts subjected to combined bending and twisting loads, equivalent twisting moments and equivalent bending moments. Members subjected to combined axial, bending and torsional loads.

Theories of Elastic Failure: The necessity for theory, different theories, significance and comparison.

Unit 4

Energy Methods: Principal of virtual work, reciprocal theorems, unit load method. Strain energy and complementary strain energy. Strain energy due to axial, bending and torsional load. Castigliano's theorems. Application of energy methods for determination of deflections of simple structural members and structures, deflection of beam due to shear.

Text Books/References:

1. James M. Gere and Stephen P. Timoshenko: Mechanics of Materials (2^{nd} ed.), CBS Publishers & Distributors, Delhi.
2. B. C. Punmia: Strength of Material and Mechanics of Structures (Vol. I), Standard Publishers and Distributors, New Delhi.
3. S. H. Crandall, N. C. Dahl and S.J. Lardner: An Introduction to Mechanics of Solids, TMH.
4. E.P. Popov: Introduction to Mechanics of Solids, Prentice Hall.
5. B.C. Punamia, Ashok Kumar Jain, Arun Kumar Jain, Mechanics of Material, 2016. Laxmi Publication (P) Ltd., New Delhi

ME242 (PCC) ENGINEERING THERMODYNAMICS

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Apply laws of thermodynamics for analysis of thermodynamic systems.
CO2: Understand thermodynamic relation for those properties that cannot be measured directly in terms of easily measurable properties.
CO3 Understand properties of pure substances and theoretical foundation for development of tables for thermodynamic properties.
CO4: Represent processes on phase diagrams and compute properties.
CO5: Analyse chemical equilibrium and mixture of gases and vapours.

Unit 1

Introduction: Microscopic and macroscopic points of view, limits of Thermodynamics. Homogeneous and heterogeneous systems, thermodynamic properties and state, heat and work.

Zeroth Law of Thermodynamics: Thermodynamic equilibrium, thermodynamic and international practical temperature scales.

First Law of Thermodynamics: Application to non-steady flow processes. Comparison of SFEE and Bernoulli's equation. Variable specific heat, processes involving variable specific heat, energy charts.

Unit 2

Second Law of Thermodynamics: Equivalence of Kelvin-Planck and Clausius statements. Reversible and irreversible cycle. Carnot cycle. Corollaries of second law and entropy, Clausius inequality, principle of increase of entropy. Availability, irreversibility and efficiency. Second law analysis of systems.

Thermodynamic Relations: Differential relationship for systems of constant composition. Helmoltz and Gibbs function. Variable specific heat. Joule-Kelvin coefficient, Clausius-Clapeyron equation.

Unit 3

Properties of Pure Substances: Ideal gas, PVT surfaces, equation of state, Vander Waal's equation. Beattie-Bridgeman equation and other equations of state. Virial coefficients. Law of corresponding states, use of generalized compressibility charts. Development of table for thermodynamic properties. Phase diagrams between various properties. Representation of processes in various phase diagrams.

Unit 4

Mixture of Gases and Vapours: Vapour mixture. Mixture of ideal gases, Dalton's law, Amagat-Ledue law, Gibb's Law. Irreversible mixing process for ideal gases, mixture of ideal gases and vapour. Gravitational and volumetric analysis.

Chemical Equilibrium: Thermodynamics of combustion, internal energy and enthalpy of formation, first and second law analysis.

Text Books/References:

1. P. K. Nag. Engineering Thermodynamics, TMH.
2. C. P. Arora: Engineering Thermodynamics, TMH.
3. E. Rathakrishnan. Fundamentals of Engineering Thermodynamics, PHI.
4. Y. Cenegel and M. Boles. Thermodynamics: An Engineering Approach, McGraw-Hill.

ME243 (PCC) MANUFACTURING PROCESSES- II

	L	T	P
Credit	3	0	1
Hours	3	0	2

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Understand important characteristics and technological aspects of bulk forming and sheet metal working processes.
CO2: Describe powder metallurgy and plastic processing.
CO3 Describe manufacturing processes for screw threads and gears.
CO4: Explain abrasive machining and super finishing processes.
CO5: Demonstrate knowledge of unconventional machining methods.

Unit 1

Lathes: Classification. Constructional details, principal parts, accessories, attachments, and work holding devices of centre lathe. Main operations including taper turning and thread cutting, change gear calculation. Lathe tools.

Batch and Mass Production Machines: Capstan and turret lathes. Automatic machine tools- Single and multispindle automats, their operation and tool layout. Hydraulic tracer controlled machine tools.

Shaper: Classification. Constructional details and principal parts of standard shaper, quick return and feed mechanisms, hydraulic shaper. Shaper tools, work holding devices and main operations.

Unit 2

Planer Machines: Classification, principal parts of standard planer, table drive and feed mechanisms. Main operations, tools, and work holding devices.

Drilling Machines: Classification. Constructional details of sensitive, pillar and radial drilling machines. Work and tool holding devices. Main operations. Tools, twist drill, reamer and tap.

Boring Machines: Classification. Horizontal and vertical boring machines. Precision boring machines, jig boring machines. Principal operations, boring tools, work holding devices. Broaching Machines and tools

Unit 3

Milling Machines: Types and classification, Constructional details parts and principle of operation of horizontal, vertical, and universal milling machines. Work and cutter holding devices, attachments. Milling cutters. Milling operations and processes. Indexing methods and gear cutting.

Introduction to principles and operations of numerically controlled machine tools, machining centre, transfer machines and methods.

Unit 4

Abrasive Machining: Types and classification. Surface, cylindrical and centreless grinding. Tool and cutter grinders. Grinding wheels, abrasives, bonding processes, selection of grinding wheels. Honing, lapping, polishing, buffing and super-finishing method.

Unconventional Machining Methods: Abrasive jet, electric discharge, electrochemical, ultrasonic, electron beam, plasma arc and laser beam machining. Electrolytic grinding, chemical milling.

Practicals:

Exercises on lathe, shaper, planer and milling machines, Gear cutting.

Text Books/References:

1. J.S. Campbell: Principles of Manufacturing Materials and Processes, Tata McGraw-Hill Company Ltd, New Delhi.
2. P.C. Sharma: A Text Book of Production Technology, S. Chand & Co., New Delhi.
3. S.K. Hajra Choudhury and A.K. Hajra Choudhury: Elements of Workshop Technology, Vol. I. Media Promoters & Publishers Pvt. Ltd., Bombay.
4. Pandey and Shan: Modern machining Process, TMH.
5. Amitabha Bhattacharyya: New Technology, published by the Institution of Engineers, India

ME244 (PCC) DYNAMICS OF MACHINES

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Solve static and dynamic force analysis problems for simple mechanisms.
CO2: Compute the fluctuation of speed and size of flywheel for various applications.
CO3 Analyse effects of precessional motion in mechanical systems.
CO4: Demonstrate knowledge and application of lubrication and friction theories.
CO5: Analyse various types of governor mechanism.
CO6: Solve balancing problems in mechanical systems.

Unit 1

Static Force Analysis: Conditions for equilibrium, free body diagrams. Static force analysis of simple four-bar linkages, slider crank mechanisms, cam-follower systems and gear systems with graphical and analytical methods. Consideration of friction.

Dynamic Force Analysis: Inertia force and torque, D' Alembert's principle, principle of superposition. Graphical and analytical dynamic force analysis of four bar mechanism and slider crack mechanism. Shaking forces and moments. Dynamically equivalent systems, application to single cylinder reciprocating engines. Gas force, bearing loads, shaft torque, shaking forces and moments determination.

Unit 2

Flywheel: Turning moment diagrams, coefficient of fluctuation of speed and energy, mass of flywheel, flywheel applications.

Gyroscopic Forces: Precessional motion, gyroscopic couple. Effect on stability of ships and aeroplanes, effect on four wheeled and two wheeled vehicles negotiating a curve, gyroscopic stabilisation of ships.

Unit 3

Friction and lubrication: Dry friction, static and dynamic friction. Friction on inclined plane, friction of pivots and collars, single and multiple disc clutches. Friction circle of turning pair and friction axis of a link. Rolling friction, antifriction bearings. Viscous and greasy friction. Film lubrication, hydrostatic lubrication.

Governor: Types of governors. Analysis of Watt, Porter, Proell and spring loaded governors. Effect of friction, controlling force curves, sensitiveness, stability, hunting, isochronism and effort of governor. Inertia governors.

Unit 4

Balancing: Static and dynamic unbalance. Balancing of rotating masses in one and different planes, analytical and graphical methods. Balancing of reciprocating engines, primary and secondary inertia forces. partial primary balancing of locomotives, variation of tractive effort, swaying couple, hammer blow. Balancing of coupled locomotives. Balancing of multicylinder inline and radial engines, direct and reversed crank method, balancing of V engines. Balancing machines.

Text Books/References:

1. Joseph E. Shigley and John J. Uicker, Jr.: Theory of Machines and Mechanisms, McGraw Hill Inc.
2. P. L. Ballaney: Theory of Machines, Khanna Publishers, Delhi.
3. R. S. Khurmi and J. K. Gupta: Theory of Machines, Eurasia Publishing House (Pvt.) Ltd., New Delhi.
4. H. H. Mabie and C. F. Reinholtz: Mechanisms and Dynamics of Machinery. John Wiley & Sons.
5. Amitabha Ghosh and A. K. Mallik: Theory of Mechanisms and Machines, Affiliated East West Press Pvt. Ltd., Delhi.

ME245 (ESC) COMPUTER GRAPHICS LAB (CAD LAB-I)

	L	T	P
Credit	0	0	2
Hours	0	0	4

Course Outcomes:	**Upon completion of this course the students, using any CAD software such as AutoCAD,will be able to:**
CO1:	Demonstrate knowledge of various menus, tool bars, commands and their options.
CO2:	Draw, edit, manipulate and plot scaled, annotated and dimensioned 2-D drawings.
CO3	Use different types of line types, line weights, layers, hatching styles, dimension and text styles, etc. for the drawings.
CO4:	Demonstrate ability to use efficiency enhancing features like use of short cuts, context menus, use of coordinate system, blocks, drafting setting, etc.

Introduction to Computer Aided Drafting using popular softwares like AutoCad. Drawing entities. Drawing, modifying, viewing, printing and dimensioning commands. Drawing aids, coordinate systems, layers, hatching, etc. Blocks. Simple 2-D drawing and dimensioning exercises.

Text Books/References:

1. AutoCad: Reference Manual
2. George Omura: Mastering AutoCad.

ME246 (PCC) STEAM POWER ENGINEERING

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Understand high pressure & super critical boilers and boiler testing.
CO2: Apply thermodynamic, heat balance and draft analysis to boiler systems.
CO3 Analyse practical vapour power cycles.
CO4: Describe steam power plant components like turbines, condensers and nozzles.
CO5: Analyse steam turbines, condensers and nozzles.

Unit 1

Steam Generators: Natural circulation and forced circulation high pressure boilers viz. Lamont, Loeffler, and Benson boilers. Introduction to super critical pressure boilers. Testing of boiler. Heat balance sheet, problems involving combustion.

Boiler Draught: Boiler draught. Natural draught, height of chimney. Artificial draught, fans. Equivalent evaporation, efficiency and heat balance.

Unit 2

Vapour Power Cycles: Rankine cycle, effect of thermodynamic variables on its efficiency. Reheat cycle. Regenerative cycle, efficiency, disposal of bled steam, condensate. Regenerative water extraction cycle. Binary vapour cycle. Steam for heating and process work, back pressure turbine, pass out or extraction turbine, mixed pressure turbine. Second law analysis of steam power plant.

Unit 3

Condensers: Elements of condensing plant, advantages. Jet, surface, and evaporative condensers. Air in condenser and methods of extraction. Vacuum and condenser efficiency, cooling water requirement, capacity of air pump.

Steam Nozzles: Type of nozzles, steam flow through nozzles, application of SFEE, critical pressure, throat and exit areas for optimum discharge, friction effect. Super saturation phenomenon, effect of variation of back pressure. Theory of steam injectors.

Unit 4

Steam Turbines: Types and classification. Impulse and reaction turbines. Flow of steam through turbine, blade sections and height. Velocity diagrams, application of SFEE. Diagram, stage and other efficiencies, condition for maximum efficiency. Methods of reducing rotor speed for turbines. Reheating and bleeding of turbines, reheat factor. Turbine characteristics and performance. Methods of governing, emergency governors.

Turbine Construction Details: Steam turbine components description. Nozzles, rotors, blades and their attachment, turbine glands, couplings. Balancing of axial thrust.

Text Books/References:

1. M.L. Mathur and F.S. Mehta: Thermal Engineering, (Vol. I & II, SI Edition), Jain Brothers, New Delhi.
2. R. Joel: Basic Engineering Thermodynamics: Pearson Education.
3. G. Rogers and Y. Mayhew: Engineering Thermodynamics Work and Heat Transfer, Pearson Education.
4. R. K. Purohit: Mechanical Engineering (SI Units), Scientific Publishers, Jodhpur.

THIRD YEAR B.TECH. (Mech. Engg.) – V Semester

ME351 (PCC) MECHANICAL VIBRATIONS

	L	T	P
Credit	3	0	1
Hours	3	0	2

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Make and solve mathematic models for analysis of vibrations of single degree of freedom (SDOF) systems.

CO2: Determine the transmissibility of SDOF systems with harmonic excitation.
CO3 Demonstrate the knowledge of principles and applications of vibration measuring instruments and vibrations isolation materials.
CO4: Formulate and solve governing equations for MDOF undamped systems with analytical and approximate/numerical methods.
CO5: Model and solve the continuous system.
CO6: Compute the critical speed for shafts having upto two rotors.

Unit 1

Vibrations: Types of vibrations. Degrees of freedom, continuous and lumped systems, natural frequency, resonance. Simple harmonic motion, vectorial and complex number representation. Fourier series and harmonic analysis.

Undamped Free Vibrations: Formulation of equations of motion for single degree of freedom system by Newton's law, D'Alembert's principle and by energy approach. Solutions for given initial conditions for simple systems. Free flexural and torsional vibrations. Equivalent stiffness.

Unit 2

Damped Free Vibrations: Types of damping, free damped vibrations of single dof system with viscous damping. Damping coefficient and factor. Overdamped, critically damped, and underdamped systems. Logarithmic decrement. Viscous dampers. Frequency and rate of decay of amplitude with Coulomb damping.

Forced Vibrations: Forced vibrations with constant harmonic excitation, transient and steady state solutions. Magnification factor and phase difference. Forced vibrations with rotating unbalance, reciprocating unbalance, and with motion excitation of support. Non harmonic excitation. Vibration isolation and transmissibility, material for vibration isolation. Principles of vibration measuring instruments.

Unit 3

Multi Degree of freedom Systems: Introduction to concepts of coupling of equations of motion, principal modes, orthogonality of modes, mode shapes, modal matrix. Free vibrations of simple two degree of freedom rectilinear and torsional systems. Undamped vibration absorbers.

Approximate and numerical method for multi degrees of freedom systems- Rayleigh's method, Dunkerley's method and Holzers's method. Application to simple systems. Geared systems.

Unit 4

Continuous Systems: Discrete vs. continuous systems. Free vibrations of strings, longitudinal and transverse vibrations of beams, torsional vibrations of shafts.

Critical Speeds of Shafts: Whirling of shafts, critical speed of light shaft having single rotor with and without damping, critical speeds of shaft with two rotors. Secondary critical speed.

List of Practicals:

Experimental verification of gyroscopic effect, Experiment on Governors, Balancing experiment, Whirling of shafts, Experiments on single and multiple degrees of freedom systems.

Text Books/References:

1. G. K. Grover: Mechanical Vibrations, Nem Chand & Bros., Roorkee.
2. Francis S. Tse, Iwan E. Morse and Rolland T. Hinkle: Mechanical Vibrations, CBS Publishers & Distributors, Delhi.
3. Leonard Merovitch: Elements of Vibrations Analysis (International Edition), McGraw Hill Inc, Singapore.
4. W. T. Thomson, Theory of Vibrations and Applications, Prentice Hall.

ME352 (PCC) FLUID MECHANICS

	L	T	P
Credit	3	0	1
Hours	3	0	2

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Analyse hydrostatic forces and stability of floating bodies.
CO2: Apply fundamental equations of mass, momentum and energy conservation to solve problems in ideal and viscous fluid flow.
CO3 Analyse problems in pipe flow networks.
CO4: Apply the principles of dimensional analysis and similitude to establish functional relations between

important relevant parameters in fluid mechanics problems.
CO5: Explain the phenomenon of boundary layer and flow around bodies.
CO6: Demonstrate knowledge of various flow and pressure measuring devices.

Unit 1

Introduction: Continuum concept. Viscosity, effect of temperature and pressure. Incompressible and compressible fluids, Newtonian and Non Newtonian fluids, ideal fluid. Surface tension, capillarity, vapour pressure and cavitation.

Fluid Statics: Pressure, units and scales of measurement, general differential equation, manometry. Fluid forces on submerged surfaces. Buoyant force, stability of floating and submerged bodies, metacentric height.

Governing Equations of Fluid Flow: Flow classifications, stream, streak and path lines. Generalised continuity equation, Euler's equation of motion, Bernoulli's equation, momentum equation, angular momentum equation, and their application to fixed and moving blades, vanes, jets, etc.

Flow Measurement: Free orifice, jet, vena contracta. Orifice in pipes. Mouthpiece, venturimeter, notches and weirs.

Unit 2

Ideal Flow: Irrotational flow, velocity potential, Laplace's equation, stream function. Flow net, vortex and circulation. Potential flow solution for two dimensional problems, superposition, half body, Rankine body, circular cylinder and circular cylinder with circulation. Tormado Method of images, additional methods for obtaining potential flow solution.

Viscous Flow: Equation of motion for viscous fluid, Navier-Stokes equations. Laminar and turbulent flow, Reynold's experiment. Simple solution of Navier-Stokes equations for laminar flow between parallel plates, circular and annular tubes. Hagen-Poiseuille flow, plane Poiseuille flow and Couttee flow. Turbulent flow, mixing length hypothesis applied to pipe flow, velocity distribution in smooth and rough pipes.

Unit 3

Flow Through Pipes: Head loss and friction in rough and smooth pipes, Darcy-Weisbach equation, variation of friction factor with Reynold's number, Prandtl number. Universal pipe friction flows, Colebrook formula. Loss of head due to sudden enlargements, contraction, entrance, exit, obstruction, bend, pipe fittings. Total energy and Hydraulic gradient lines. Flow through pipe line, pipes in series and parallel. Transmission of power through pipes.

Dimensional Analysis and Dynamic Similitude: Buckingham's theorem, Superfluous and omitted variables. Dimensionless ratios. Reynold, Froude, Mach, Weber, and Euler numbers, and their applications. Similitude, model studies, undistorted model, distorted model, scale effect.

Unit 4

Boundary Layer: Description of boundary layer, boundary layer thickness, boundary layer separation and control. Prandtl boundary layer equation and solution. Laminar boundary layer, momentum equation for the boundary layer on flat plate in uniform free stream with no pressures gradients; Approximate momentum analysis -Laminar boundary layer, Turbulent boundary layer, Viscous sublayer, combined Laminar and turbulent boundary layers.

Flow Round a Body: Drag, skin friction drag, pressure drag, Combined skin friction and pressure drag (profile drag),wave drag, lift induced drag. Flow past sphere and cylinder.

Practicals:

Verification of Bernoulli's theorem. Measurement of flow through venturimeter, orifice, notches and mouthpieces and determining their coefficient of discharge. Flow through pipes and measurement of fluids.

Text Books/References:

1. Victor L. Streeter: Fluid Mechanics, McGraw Hill Book Co., Singapore.
2. R. K. Rajaput: Fluid Mechanics and Machines, S. Chand & Co.
3. R. K. Bansal: Fluid Mechanics and Hydraulic Machines, 9th edition, Laxmi Publications (P) Ltd.,
4. Irving Shames: Mechanics of Fluids, McGraw Hill.
5. R.K. Purohit: Fundamentals of Fluid Mechanics, Scientific Publication, Jodhpur.

ME353 (PCC) PRODUCTION ENGINEERING & TECHNOLOGY

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Describe cutting tools by standard tool signature systems.
CO2: Understand mechanics of metal cutting by single & multi point cutting tools and chip formation.
CO3 Compute tool life and optimum cutting speed for given data.
CO4: Explain characteristics of tool material and cutting fluids.
CO5: Estimate forces and power requirements in metal forming operations.
CO6: Demonstrate knowledge of design principles of forming & cutting tools, jigs & fixtures.
CO7: Demonstrate knowledge of safety codes, device & practice in industry.

Unit 1

Mechanics of Metal Cutting: Geometry of single point and multi point cutting tools, tool signature systems. Orthogonal and oblique cutting. Mechanism and geometry of chip formation, types of chips. Forces on chips. Velocity, stress, strain and strain rate, power, and energy relationships in orthogonal cutting. Theories on metal cutting. Friction and thermal aspects, measurement of cutting force and chip-tool interface temperature. Mechanics of multipoint cutting tools viz. milling, drilling and broaching tools.

Unit 2

Theory of Machinability: Evaluation of machinability, tool life, tool failure. Mechanisms of tools wear, effect of cutting parameters, surface finish. Economics of machining, optimum cutting speed. Cutting tool materials and their characteristics, chip breakers, cutting fluids and their applications.

Unit 3

Metal Working Analysis: Fundamentals of theory of plasticity, flow conditions, plane strain criterion, friction in metal working. Elementary analysis of wire drawing, tube drawing, rod and strip drawing. Theory of forging. Elementary theory of rolling, Nadai's theory of rolling, rolling power requirement calculation.

Unit 4

Tool Design: Design Principles of forging and sub-setting dies, elements of design of sheet metal press tools and dies. Design of single point cutting tools, form tools, and milling cutters.

Jigs and Fixtures: Introduction, design considerations and materials. Principles of location. Clamping and locating devices. Drilling jigs and bushes. Classification and types of milling fixtures.

Safety Engineering: Safety devices in production shops, safety codes.

Text Books/References:

1. S.K. Hajra Choudhury and A.K. Hajra Choudhury: Elements of Workshop Technology, Vol. II, Media Promoters & Publishers Pvt. Ltd., Bombay.
2. R.K. Jain & SC Gupta: Production Technology, Khanna Publishers, New Delhi.
3. JS Campbell: Principles of Manufacturing Materials and Processes, Tata McGraw-Hill Company Ltd, New Delhi.
4. H.M.T. Publication, Production Technology, Tata McGraw-Hill.

ME354 (PCC) IC ENGINES

	L	T	P
Credit	3	0	1
Hours	3	0	2

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Understand the combustion phenomenon in IC engines.
CO2: Understand the fuel delivery and ignition systems of IC engines.
CO3 Describe properties of IC engine fuels and their relationship to engine performance.
CO4: Explain engine lubrication &cooling systems.
CO5: Describe working and operation of two-stroke IC engines, scavenging, supercharging, dual/multi

fuel-, free piston-, rotary combustion engines.
CO6: Accomplish performance analysis and testing of IC engines.
CO7: Demonstrate knowledge of causes and control of engine emissions.

Unit 1

Introduction: Classification, various engine efficiencies and performance parameters. Basic air cycles, deviations from ideal cycles.

Combustion in S.I. Engines: Ignition limits. Stages of combustion, effect of engine variables on flame propagation, rate of pressure rise. Abnormal combustion, detonation or knocking, effects and control of detonation, theories and chemistry of detonation, effect of engine variables on detonation. Abnormal combustion.

Carburetion: Properties of air-fuel mixtures, mixture requirements for different engine conditions. Transient mixture requirements. Elementary carburettor, calculation of air-fuel ratio. Description of important carburettors. Petrol injection, electronic fuel injection.

Ignition System of SI Engines: Types of basic ignition systems. Firing order, ignition timings, ignition advance mechanisms. Spark plugs. Electronic ignition system.

Unit 2

Combustion in CI Engines: Stages of combustion. Air-fuel ratio in CI engines. Variables affecting delay period. Diesel knock, effect of engine variables, control of diesel knock. Cold starting of CI engines.

Combustion Chambers: Requirements and design principles of combustion chambers, main features of widely used combustion chambers for SI and CI engines.

Fuel injection: Heat release pattern, types of injection systems. Types of fuel pumps, injectors, and injector nozzles. Injection timing.

Unit 3

Engine fuels and Combustion: Fuels for SI engines, gasoline, requirements of ideal gasoline. Effect on engine performance. Knock rating of SI fuels, HUCR, Octane number, research and motor octane numbers. Important properties of diesel fuel. Cetane number, diesel index, Aniline point. Fuel additives or dopes. Exhaust gas analysis.

Two Stroke Engines: Introduction, valve timings. Scavenging processes and parameters, scavenging systems, scavenging pumps.

Introduction to free piston, rotary combustion, dual fuel, and multi-fuel engines. Effect of atmospheric conditions on performance of I.C. Engines. Supercharging, methods and types of super charging.

Unit 4

Engine Friction, Lubrication and Cooling: Break up of total engine friction, effect of engine variables on engine friction. Lubrication systems. Lubricating oils, classification, properties and service ratings. Oil pumps and filters. Crankcase ventilation. Areas of heat flow and temperature distribution, necessity of cooling. Types of cooling systems, air and water cooling. Thermostatic control. Radiators and cooling fans.

Performance and Testing: Performance parameters. Measurement of speed, fuel and air consumption, brake horse power. Friction horse power measurement methods. Indicated power measurement, high speed indicators. Performance of SI and CI engines, heat balance sheet.

Air Pollution: Introduction to air pollution, causes and control of air pollution.

Practicals:

(A) IC Engine Lab

1. To Study four strokes spark ignition (S.I) Engine and differences between S.I. ad C.I engines.
2. To study two Strokes S.I. engine and differences between two strokes and four strokes engines
3. To study battery ignition system for four cylinders S.I. engines and requirements of ignition system.
4. To study magneto ignition system for SI engine having four cylinders and differences between magneto and battery Ignition system.
5. Study of multi-point fuel injection (MPFI) system.
6. To study performance of four stroke four cylinder diesel engine with rope break dynamometer.

(B) Steam Power Engineering Lab

1. To study high pressure boilers La-Mont Boiler and Benson Boiler.
2. To conduct boiler trial test and obtain its efficiency.
3. To study of steam turbines.
4. To study steam condensers.
5. To study volumetric analysis of dry flue gases by Orsat apparatus.

6. To determine calorific value of coal by Bomb calorimeter.

Texts/References:

1. M. L. Mathur and R. P. Sharma: A Course in Internal Combustion Engines, Dhanpat Rai & Sons, Delhi.
2. Ganesan: IC Engines, TMH.
3. J. Heywood: Internal Combustion Engine Fundamentals, McGraw Hill.

ME355 (PCC) MACHINE DESIGN-I

	L	T	P
Credit	3	1	0
Hours	3	1	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Identify considerations for design and selection of materials, factor of safety and standard sizes as per relevant codes/standards for machine components.
CO2: Demonstrate understanding of various theories for design under static and cyclic loading.
CO3 Analyse stresses and strains in components, identify the failure criteria and apply appropriate theory of failure for design.
CO4: Design joints, curved members, beams, levers and columns.
CO5: Design shaft, coupling, helical spring and laminated springs.

Unit 1

Introduction: Meaning and phases of design, design process, design considerations. Engineering materials and their mechanical properties, BIS designation of materials. Preferred numbers. Factor of safety, selection of allowable stresses. Types of load and stresses, impact loads, theories of failure. Stress concentration, theoretical stress concentration factors and charts. Stress intensity factor and fracture toughness. Fatigue, S-N diagram, endurance limit and modifying factors, fatigue stress concentration factor, design for fatigue, fluctuating stresses, Soderberg, Goodman and modified Goodman formulae. Surface endurance shear.

Design of Beams and levers.

Unit 2

Design of Detachable Joints: Cottered joints, pinned joints and turnbuckle. Design of bolted joints with and without preload, gasketed joints, design under fatigue loading. Bolted joints subjected to eccentric loading. Design of nuts, types of locking devices.

Design of Curved Members: Design of crane hooks, circular rings, chain rings, chain links, etc.

Unit 3

Design of Permanent Joints: Design of riveted joints, structural and pressure vessel (boilers) riveted joints, joints under eccentric loading. Design of welded joints. Eccentric loading on riveted and welded joints.

Design of columns.

Unit 4

Design of Shafts, keys, couplings. Design of helical and laminated springs. Fatigue considerations.

Text Books/References:

1. V. B. Bhandari: Design of Machine Elements, TMH.
2. Joseph Edward Shigely: Mechanical Engineering Design, McGraw Hill Book Company, Singapore.
3. R. S. Khurmi and J. K. Gupta: A Text Book of Machine Design, Eurasia Publishing House (Pvt.) Ltd., New Delhi.
4. N. C. Pandya and C. S. Shah: Elements of Machine Design, Charotar Book Stall, Anand.

NOTE:

Design Data Hand Book is NOT provided to the students in the examination. The questions must be self-complete in respect of any design data, empirical formulae, factors, constants, etc. or any such data which are not reasonably expected to be remembered by the students.

ME357 (ESC) CAD LAB-II

	L	T	P
Credit	0	0	2
Hours	0	0	4

Course Outcomes:	Upon completion of this course the students, using any solid modelling software such as CATIA, SOLIDWORKS or any other software as per availability, will be able to:
CO1:	Demonstrate the concepts of parametric solid modelling.
CO2:	Set different sketch planes, reference planes and axes.
CO3	Create sketches and generate features to make a solid part.
CO4:	Learn to make complex part using Boolean operations.
CO5:	Create an assembly of parts and generate orthographic projections.

Solid modeling using popular software like Mechanical Desktop, Inventor, CATIA, Pro-Engineer, or Ideas.

Drawing curves and surfaces. Extruded solids. 3-D primitives. 3-D operations like union, intersecting, etc. 3-D transformation. Making a part from sketch, Assembling different parts. Simple 3-D modeling exercises

The students is expected to master modeling simple parts using any one of the packages as per availability.

Writing Programmes in C and/or MATLAB for numerical solutions of problems related to mechanical engineering. Use of statistical packages, data presentation packages, etc.

Texts/References:

Reference Manuals of the relevant software.

ELECTIVE-I

ME356(a) (PEC) FINITE ELEMENT METHOD

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes:	Upon completion of this course the students will be able to:
CO1:	Derive variational and Galerkin formulation of field problems and be able to identify the essential and natural boundary conditions.
CO2:	Apply principle of stationary (or minimum) potential energy to derive finite element formulation of solid mechanics and heat transfer problems.
CO3	Derive elemental matrices from various interpolation schemes & shape functions.
CO4:	Demonstrate knowledge of storage schemes and solution techniques for finite element equations.
CO5:	Assemble the elemental matrices into global matrices, apply boundary conditions using penalty and elimination approaches.
CO6:	Make and solve simple finite element models of 1-D and 2-D problems from solid mechanics and heat transfer.

Unit 1

Review of matrix algebra, theory of elasticity, stress-strain relations, strain-temperature relations, plane stress, plane strain.

Introduction to FEM with direct or stiffness formulation for bar problem. Element stiffness matrix, assembly, imposition of boundary conditions, solution of global system, stress and support reaction computation.

Computation details, storage schemes for global matrices. Solution of equations in static analysis. Gauss elimination.

Unit 2

Principle of stationary (or minimum) potential energy. Shape functions, degree of continuity, interpolation. Shape functions for C^0 and C^1 elements. General displacement based formulation for structural problems. Consistent element nodal loads. Equilibrium and compatibility in FE model.

Finite element formulation for one dimensional bar and heat transfer problems. Linear and quadratic elements. Natural coordinates, isoparametric formulation.

Unit 3

Finite element formulation of one dimensional beam problem from minimum potential energy approach. Beam element. Coordinate transformations, truss elements and frame elements. Application to simple beam and trussproblems.

Unit 4

Finite element formulation for two dimensional structural problems – minimum potential energy approach. Natural (area) coordinates. Constant strain triangular (CST) elements for structural problems. Plane bilinear element.

Text Books/References:

1. T. R. Chandrupatla and A. D. Belegundu: Introduction to Finite Elements in Engineering, Prentice Hall of India, New Delhi.
2. R. D. Cook, D.S. Malkus and M.E. Plesha: Concepts and Applications of Finite Element Analysis, John Wiley & Sons.
3. P. Sheshu: Text Book of Finite Element Analysis, Prentice Hall of India.
4. K.J. Bathe: Finite Element Procedure, Prentice Hall of India.

ME356(b) (PEC) COMPUTER AIDED DESIGN

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Explain CAD hardware, application areas and advantages.
CO2: Demonstrate knowledge of optimization techniques.
CO3 Describe algorithms employed for generation of graphical primitives, windowing and transformation.
CO4: Understand analytical as well as synthetic approaches for curve design and features of solid modelling techniques.
CO5: Apply mathematic techniques for modelling of curves & surfaces and their manipulation.

Unit 1

Design process, application of computers for design, definition of CAD, benefits of CAD. CAD system components. Computer hardware for CAD. Display, input and output devices.

Unit 2

Optimisation methods in design. General techniques, exact and iterative techniques. Optimal design of elements and systems. Applications to design of forging, shafts, gears, etc. Role of optimisation techniques and finite element method in CAD.

Unit 3

Computer Graphics: Graphics primitives, display file, frame buffer, display control, display processors. Line generation, graphics software. Points and lines, DDA and Bresenham's line algorithms, antialiasing lines. Polygons, filling of polygons. Bresenham's algorithm for drawing circle and ellipse. Text primitive. Other primitives. Windowing and clipping, viewport. Homogeneous coordinates. Transformations.

Unit 4

Planar and space curves design. Analytical and synthetic approaches. Parametric and implicit equations. B-spline and Beizer curves. Modelling of biparametric freeform surfaces. Coons and Beizer surface patches. Surface manipulation techniques.

Geometric modelling techniques. Wire frames. Introduction to solid modelling.

Text Books/References:

1. D.F. Rogers and A. Adams: Mathematical Elements for Computer Graphics, McGraw Hill Inc., New York
2. I.D. Faux and M.J. Pratt: Computational Geometry for Design and Manufacture, John Wiley & Sons, NY.
3. Steven Harrington: Computer Graphics- A Programming Approach, McGraw Hill.
4. M. P. Groover and E.W. Zimmers: CAD/CAM- Computer Aided Design and Manufacturing, PHI, New

Delhi.
5. Surendra Kumar and A.K. Jha: Technology of Computer Aided Design and Manufacturing CAD/CAM, Dhanpat Rai & Sons, Delhi.

ME356(c) (PEC) VIBRATION AND NOISE CONTROL

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Demonstrate comprehension of vibration of single, and multi degree of freedom systems.
CO2: Formulate governing equations using Lagrange's equations.
CO3 Explain fundamentals of noise and methods of noise control.
CO4: Demonstrate knowledge of vibration and noise measurement instruments.
CO5: Perform numerical analysis of vibration and noise problems.

Unit 1

Vibration theory, vibration of one degree-of-freedom systems. Two and multi degree of freedom systems. Transient vibrations. Vibration of beams. Langrange's equation.

Unit 2

Basic noise theory, noise and vibration criteria, sound waves and their propagation, acoustic impedance, noise analysis, transmission of noise, human response to noise.

Unit 3

Vibration and noise measuring and analysing instruments. Principle of vibration and noise control.

Unit 4

Numerical treatment of vibration and noise problems. Analysis of a practical problem.

Text Books/References:

1. W.T. Thomson: Theory of Vibration and Applications, Prentice Hall.
2. R.F. Steidl: An Introduction to Mechanical Vibration, John Wiley and Sons.
3. L.L. Beranek: Noise Reduction, McGraw Hill.

ME356(d) (PEC) OPTIMIZATION METHODS IN ENGINEERING DESIGN

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Understand the classical optimization techniques.
CO2: Solve one dimensional minimisation techniques.
CO3 Explain geometric programming techniques.
CO4: Model and solve multidimensional optimizations problems.
CO5: Model and solve linear programming problems.

Unit 1

Need for optimisation and historical development. Classification and formulation of optimisation problems, classical optimisation methods, differential calculus, Lagrangian theory, Kuhn Tucker condition.

Unit 2

Unconstrained minimisation techniques, one dimensional minimisation techniques Fibonnacci, Goldern section and quadratic interpolation methods.

Unit 3

Multi-dimensional minimisation, Univariate, Conjugate direction, gradient and variable metric methods. Constrained minimisation techniques, penalty function methods, feasible direction and gradient projection methods. Introduction to geometric programming.

Unit 4

Linear programming and simplex method. Examples and applications of the above methods in the recent engineering design literature.

Text Books/References:

1. S.S. Rao: Optimisation-Theory and Applications, Wiley Eastern Ltd.
2. R.L. Fox: Optimisation Methods for Engineering Design, Addison Wesley.
3. W.I. Zangwill: Non-Linear Programming, A Unified Approach, Prentice Hall.

ME356(e) (PEC) TRIBOLOGY

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Demonstrate basic understanding and control of friction, corrosion and wear processes.
CO2: Describe hydrodynamic and elastohydrodynamic lubrication and bearing materials.
CO3 Design bearing for steady state and dynamic loads.
CO4: Apply mathematic fundamentals to solve lubrication problems.
CO5: Demonstrate knowledge of tribology problems under extreme environmental conditions.
CO6: Demonstrate knowledge of experimental techniques in tribology.

Unit 1

Metrology of surfaces. Nature of friction and wear processes. Coatings for wear resistance. Theory, testing and control of corrosion.

Unit 2

Lubricants and bearing materials. Hydrodynamic lubrication. Steady state and dynamically loaded bearing design.

Unit 3

Elastohydrodynamic lubrication, rolling element bearings and gear lubrication.

Unit 4

Lubrication problems at certain extreme environment conditions, e.g., pressure, temperature and vacuum. Experimental techniques in tribology.

Text Books/References:

1. E.R. Braithwaite: Solids, Lubricants and Surface, Pergamon.
2. F.P. Bowden and D. Tabor: Friction and Lubrication of Solids, Oxford University Press.
3. A. Cameron: Principles of Lubrications, Longmans.

THIRD YEAR B.TECH. (Mech. Engg.) – VI Semester

ME361 (PCC) HEAT TRANSFER

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Apply and solve heat conduction governing equations to one dimensional heat conduction problems.
CO2: Evaluate heat transfer performance of various types of extended surfaces.
CO3 Understand the elementary concept for transient heat transfer.
CO4: Apply empirical relations for computing heat transfer in free and forced convection.
CO5: Apply the fundamental radiation laws to compute heat transfer between black bodies for simple geometries.
CO6: Accomplish thermal design of heat exchangers.

Unit 1

Introduction: Modes and mechanism of heat transfer, basic laws. Conductivity, heat transfer coefficients.

Conduction: General differential equation of conduction. Steady state one dimensional conduction through plane and composite slabs, cylinders and spheres with and without heat generation including viscous heating, dielectric heating and linearly varying heat generation. Electrical analogy.

Insulation: Selection of insulation material and thickness of insulation. Factors influencing conductivity. Critical thickness of insulation. Thickness of insulation to prevent freezing/condensation in pipes.

Unit 2

Fins: General equation for fin.Heat transfer through fins of rectangular, triangular and parabolic profile. Effectiveness and efficiency of fin, Biot number, optimum dimensions and arrangement of fins. Thermometer well, related applications of fin theory in heat transfer from pipe flow, different temperature heat sources at ends of rods with heat generation and convection, etc.

Unsteady State Unidirectional Conduction: Newtonian heating and cooling, response of thermocouple.

Unit 3

Forced Convection: Introduction, equation of laminar boundary layer on a flat plate and in a tube, laminar forced convection on a flat plate and in a tube. Reynold's analogy. Dimensional analysis, empirical relationships.

Natural Convection: Dimensional analysis. Convection with phase change, empirical relationships, description of condensing flow, theoretical model of condensing flow. Boiling heat transfer.

Heat Exchangers: Types of heat exchangers. Log Mean Temperature Difference (LMTD). Overall heat transfer coefficient, fouling factor. Condensers and evaporators. Heat exchanger performance, effectiveness and Number of Transfer Units (NTU). LMTD and NTU methods, analysis restricted to parallel and counter flow heat exchangers.

Unit 4

Radiation: Theories of radiant heat exchange. Absorption, transmission, and reflection of radiant energy. Emission, black body and monochromatic radiation, Planck's law, total emissive power and Stefan Boltzman's law. Grey bodies, Kirchoff's law, Wien's law. Solid angle and intensity of radiation, Lambert's cosine law. Radiation exchange between black surfaces, geometric configuration factor and its determination for simple geometries. Grey body radiation exchange between surfaces. Electrical analogy and its application to simple problems. Non luminous gas radiation. Errors in temperature measurement due to radiation. Combined heat transfer coefficient with radiation and convection.

Text Books/References:

1. S. Domkundwar: A Course in Heat & Mass Transfer, Dhanpat Rai & Sons, Delhi.
2. J. P. Holman: Heat Transfer, McGraw Hill.
3. S.P. Sukhatme: A Text Book on Heat Transfer, Orient Longman.
4. Y. Cenegel: Heat Transfer - A Practical Approach, Mcgraw Hill.

ME362 (PCC) FLUID MACHINES AND SYSTEMS

	L	T	P
Credit	3	0	1
Hours	3	0	2

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Apply momentum equations to analyse turbine and centrifugal pumps for determining power and efficiency by solving velocity triangles.
CO2: Analyse performance of reciprocating pumps under different working conditions.
CO3 Apply the knowledge of unit/specific quantities, characteristics and principles of similarity to select suitable turbine and pump for given conditions.
CO4: Experimentally determine characteristic curves of pumps.
CO5: Demonstrate knowledge of hydraulic power transmission systems and common fluid machines like gear pump, etc.
CO6: Demonstrate knowledge of fluidics principles and their application in common devices.

Unit 1

Introduction: Application of momentum and moment of momentum equations to flow through hydraulic machinery, Euler's fundamental equation. Classification of machines.

Hydraulic Turbines: Classification of turbines. Impulse turbine, constructional details, velocity triangles, power and efficiency, governing of Pelton wheels. Reactions turbines, Francis and Kaplan turbines,

constructional details, velocity triangles, power and efficiency calculation, degree of reaction, draft tube, cavitation.

Principles of Similarity: Unit and specific quantities, performance characteristics, Selection of Water turbines. Thomas cavitation factor.

Unit 2

Reciprocating Pumps: Reciprocating pump, theory, indicator diagram, slip, effect of friction and acceleration, theory of air vessel.

Rotodynamic Pumps: Classification. Centrifugal pumps, vector diagrams, specific speed, head, power, and efficiency calculations. Model testing and performance characteristics. Selection of pumps.

Unit 3

Miscellaneous Fluid Machines: Gear Pumps, vane pumps, hydraulic ram, jet pumps, well pumps, deep well pumps, pumps of hydraulic pumped storage plants, air lift pump. Reversible hydraulic machines (pump turbines), types, construction and their characteristics.

Hydraulic Power Transmission: Hydro-kinetic system, function, methods of control, constant and variable delivery systems, common uses of hydrostatic systems. Hydro kinetic transmission systems, theory of hydraulic couplings and torque converters, operating characteristics, common uses of hydro kinetic systems.

Unit 4

Experimental determination of pump characteristics, pump characteristics curve from specific speed. Parallel and series connection of pumps to common pipe line. Cavitation and abrasive wear of pumps. Non Stable operation of pump.

Fluidics: Common terms, writing the logic functions in the form of algebra, The basic principle and working of devices in common use, wall attachment, jet interaction, laminar turbulent effect, vortex effect and moving part devices. Applications.

Practicals:

Study and obtaining various characteristic curves of Pelton, Francis, and Kaplan turbines. Study of and obtaining performance curves for centrifugal and reciprocating pumps.

Text Books/References:

1. Victor L. Streeter: Fluid Mechanics, McGraw Hill.
2. R. K. Rajaput: Fluid Mechanics and Machines, S. Chand & Co.
3. R. K. Bansal Fluid Mechanics and Machines,
4. Jagdish Lal: Fluid Machines
5. Irving Shames: Mechanics of Fluids, McGraw Hill.
6. R.K. Purohit: Fundamentals of Fluid Mechanics, Scientific Publishers, Jodhpur.

ME363 (PCC) INDUSTRIAL INSPECTION AND QUALITY CONTROL

	L	T	P
Credit	3	0	1
Hours	3	0	2

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Determine interchangeable limits and fits as per BIS and design limit gauges.
CO2: Demonstrate knowledge of non-destructive testing methods.
CO3 Describe metrology of surfaces, screw threads, gears and their measurement.
CO4: Demonstrate knowledge of gauge blocks, comparators, auto-collimators, optical interferometry.
CO5: Prepare sampling plans and control charts for Statistical Quality Control.
CO6: Conduct acceptance tests on machine tools and alignment tests on lathe machines.
CO7: Demonstrate knowledge of process capability, concepts of statistical tolerancing and modern quality control concepts.

Unit 1

Interchangeable Manufacture: Deviations, limits of size, tolerances, allowances, types of fits, hole basis and shaft basis systems, BIS system of limits and fits. Design of limit gauges and gauge materials, numerical problems.

Non-destructive Testing: Radiography, magnaflux and fluorescent penetrant inspection, Dye Penetrant testing, eddy current and ultrasonic tests, Alignment testing of lathes. Acceptance testing of machine tools.

Unit 2

Metrology: Dimensional and geometrical accuracy of machined surface, types of errors. Standards of measurement. Gauge blocks. Mechanical, electrical, optical and pneumatic type comparators. Auto-collimators, optical interferometry, measurement of screw threads and gears. Surface roughness specification and methods of measurement

Unit 3

Quality Control: Quality improvement, need of Control, process capability analysis, quality capability study. Statistical quality control; objective, applications, organization, cost aspects, theory of statistical tolerances.

Quality circles. Introduction to TQM; introduction to international quality certifications.

Unit 4

Statistical Quality Control: General theory of control charts, group control charts, control charts with variable sub-group *size,* moving average and moving range charts, acceptance control charts cumulative sum control charts and difference control charts.

Sampling Plans: Acceptance sampling, single, multiple and sequential sampling plans, multi-level continuous sampling, acceptance sampling by variables, sampling plans using different criteria, comparison of various types of sampling plans.

Practicals:

Exercises/study on linear and angular measurements using slip gauges and sine bar. Measurement of screw threads and gears, Experiments on ultrasonic flaw detection and measurement. Surface roughness measurement, comparators, etc. Drawing of control charts.

Text Books/References:

1. E. L. Grant: Statistical Quality Control,McGraw-Hill.
2. H.M.T. Publication, Production Technology, Tata McGraw Hill.
3. RK Jain: Engineering Metrology, Khanna Publishers, New Delhi.
4. A. Mitra, Quality control and improvement, Pearson Education, Delhi.

ME364 (PCC) REFRIGERATION AND AIR CONDITIONING

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Analyse performance of refrigeration cycles working on air, vapour compression and vapour absorption with consideration of deviations from theoretical cycles and efficiency improvement features.
CO2: Describe nonconventional and low temperature refrigeration systems.
CO3 Describe characteristics & uses of important refrigerants including modern eco-friendly refrigerants.
CO4: Demonstrate knowledge of refrigeration and air conditioning equipment.
CO5: Apply psychometric fundamentals to compute properties of air.
CO6: Estimate the heat load and determine the values of design-parameters for air conditioning systems.

Unit 1

Refrigeration: Principles of refrigeration, ice refrigeration, freezing mixtures, cooling by gas, reversible expansion, evaporation. Units of refrigeration, coefficient of performance. Heat pump.

Air Refrigeration Systems: Second law of thermodynamics applied to the refrigeration. Reversed Carnot cycle, Bell-Coleman cycle, Aircraft refrigeration.

Mechanical Vapour Compression Systems: Theoretical vapour compression system, undercooling, dry and wet compression. Deviation of actual cycle from ideal cycle. Volumetric efficiency of compressor and its effect on refrigeration cycle. Flash chambers and pre-coolers, Compound compression with intercooling, water intercooling and flash intercooling.

Unit 2

Vapour Absorption Systems: Vapour absorption cycle. Simple and practical vapour absorption system, Electrolux refrigerator.

Water vapour, steam jet, and thermo-electric refrigeration systems.

Low Temperature Refrigeration: Cascading and liquefaction of gases.

Unit 3

Refrigerants: Desirable properties of refrigerants, comparative study of the properties of important refrigerants. Eco-friendly refrigerants.

Refrigeration Equipment: Discussion of compressors, condensers, evaporators, expansion devices, cooling towers.

Unit 4

Psychrometry: Thermodynamic properties of moist air, perfect gas relationship for approximate calculation. Adiabatic saturation process, psychrometric chart and its use, elementary psychrometric processes.

Air Conditioning: Types of airconditioning, Evaluation of comfort, comfort charts. Estimation of airconditioning load. Outside and inside design conditions, condition line, sensible heat factor. Cooling and humidification, Apparatus Dew Point and bypass factor. Humidification and dehumidification methods, air washers. Air conditioning systems, plant layout, controls, transmission and distribution of air.

Text Books/References:

1. S. Domkundwar and S C Arora: Refrigeration and Air Conditioning, Dhapat Rai & Sons, Delhi.
2. J.L. Threlkeld: Thermal Environmental Engineering, Prentice Hall.
3. C.P. Arora: Refrigeration and Air-conditioning, TMH.
4. W. Stoecker: Refrigeration and Air-conditioning, McGraw Hill.

ME365 (PCC) MACHINE DESIGN-II

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Design various IC engine components viz. crank shaft, connecting rod, piston, clutch and brakes.
CO2: Design power transmission systems with rope, belt, chain and gears.
CO3 Design journal bearings.
CO4: Select appropriate type of antifriction bearing from catalogues.
CO5: Design pressure vessels, flywheel and rotating discs.

Unit 1

Design of IC Engine Components: Design of crank shaft, connecting rod, piston.

Design of clutches and brakes.

Unit 2

Design of Power Transmission Elements: Rope and chain drives, flat and V belt drives, Gear transmission systems using spur, helical, bevel and worm gears.

Unit 3

Design of screw motion mechanisms, screw jack, toggle jack, lead screw etc.

Bearings: Design of journal bearings. Selection of ball and roller bearings.

Unit 4

Design of pressure vessels: Thin cylinders and spheres. Design of thick cylindrical shells subjected to internal and external pressures. Compound cylinders. Design of cylinder heads and cover plates.

Design of flywheels and rotating discs.

Text Books/References:

1. V. B. Bhandari: Design of Machine Elements, Tata McGraw Hill, New Delhi.
2. Joseph Edward Shigely: Mechanical Engineering Design, McGraw Hill Book Company, Singapore.
3. R. S. Khurmi and J. K. Gupta: A Text Book of Machine Design, Eurasia Publishing House (Pvt.) Ltd.,

New Delhi.
4. N. C. Pandya and C. S. Shah: Elements of Machine Design, Charotar Book Stall, Anand.

NOTE:

Design Data Hand Book is NOT provided to the students in the examination. The questions must be self complete in respect of any design data, empirical formulae, factors, constants, etc. or any such data which are not reasonably expected to be remembered by the students.

ME366 (PCC) INDUSTRIAL ENGINEERING

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Demonstrate appreciation of factors and techniques for plant location and layout.
CO2: Describe material management and inventory control techniques.
CO3 Demonstrate knowledge of material handling equipment and their selection for given plant layout.
CO4: Demonstrate knowledge of various maintenance strategies.
CO5: Apply project/production planning and control techniques to simple problems.
CO6: Demonstrate use of work study techniques by solving problems for given data.
CO7: Understand concepts of value engineering and product enrichment.

Unit 1

Plant Location: Major factors, influencing the location of an industry and choice of site.

Plant Layout: Principles of plant layout, use of travel charts. Flow Pattern, Process Layout and Product Layout and combination, Line balancing.

Unit 2

Materials Management: Field and scope of material management. Material Planning and programme. Types of inventories. Inventory control. Vendor development, rating, standardisation and coding. Procedure for purchase and storage.

Materials Handling: Functions, engineering and economic factors, relationship to plant layout. Selection, operation and maintenance of material handling equipment. Types of equipment

Unit 3

Plant Maintenance: Maintenance polices, preventive, Breakdown and corrective.

Production Planning and Control: Types of production, Function of production planning and control, planning. Pre-planning, sales forecasting, routing. scheduling, despatching and control, Gantt charts. Project planning. Introduction to network techniques, CPM and PERT, time estimates.

Unit 4

Work Study: Concept of productivity, method study, motion economy, process chart symbols. Flow diagram, operation analysis and operation chart, SIMO charts. Work measurement, use of stop watch procedure for time study data. Use of time study data with practical applications. Performance rating.

Value engineering: Value engineering and value analysis, product enrichment.

Text Books/References:

1. Memoria and Agarwal: Business Organisation
2. Buffa: Operations management, student edition, Wiley, 2007.
3. R.M. Barnes: Time and Motion Study, Asia Publication.
4. Starr and Miller. Inventory Control – Theory & Practice. Prentice Hall of India.

ME368 (PEC) THERMAL ENGINEERING LAB

	L	T	P
Credit	0	0	1
Hours	0	0	2

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Apply and solve heat conduction governing equations to one dimensional heat conduction problems.
CO2: Evaluate heat transfer performance of various types of extended surfaces.
CO3: Understand the elementary concept for transient heat transfer.
CO4: Apply empirical relations for computing heat transfer in free and forced convection.
CO5: Apply the fundamental radiation laws to compute heat transfer between black bodies for simple geometries.
CO6: Accomplish thermal design of heat exchangers.

Practicals:

1. Study of domestic refrigerators and water coolers system working on vapor compression system.
2. Determine the COP and cycle efficiency of the vapour compression refrigeration system.
3. Study of one tone ice plant and its components along with study of secondary refrigerants
4. Study the working of Vapor Absorption Refrigerating system and determine COP of domestic Electrolux refrigerator.
5. Study of Air conditioning and refrigerating system components (Compressors, Expansion devices, Condensers, etc).
6. Study of psychometric chart and working of different types of air conditioner system.
7. Determine thermal conductivity of composite wall.
8. Determine the conductive heat transfer through lagged pipe apparatus.
9. Determine thermal conductivity of insulating powder.
10. Determine the temperature distribution along the pin fin length under free and forced convection heat transfer.
11. Determine the heat transfer coefficient of double heat pipe heat exchanger for parallel flow and counter flow.
12. Determine the heat transfer coefficient in natural convection.

Text Books/References:

1. S. Domkundwar: A Course in Heat & Mass Transfer, Dhanpat Rai & Sons, Delhi.
2. J. P. Holman: Heat Transfer, McGraw Hill.
3. S.P. Sukhatme: A Text Book on Heat Transfer, Orient Longman.
4. Y. Cenegel: Heat Transfer - A Practical Approach, Mcgraw Hill.
5. S. Domkundwar and S C Arora: Refrigeration and Air Conditioning, Dhapat Rai & Sons, Delhi.
6. J.L. Threlkeld: Thermal Environmental Engineering, Prentice Hall.
7. C.P. Arora: Refrigeration and Air-conditioning, TMH.
8. W. Stoecker: Refrigeration and Air-conditioning, McGraw Hill.

ELECTIVE-II

ME367(a) (PEC) ADVANCED JOINING TECHNOLOGY

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Analyse welds for heat flow in fusion welding.
CO2: Demonstrate knowledge of heat treatment and welding metallurgy.
CO3 Explain characteristics and application areas of modern welding processes.
CO4: Describe welding processes for plastics, ceramics and composites.
CO5: Design weldments for pressure vessels, heavy structures, offshore structures and submarine pipe lines.
CO6: Undertake inspection and testing of welds using standard codes.

Unit 1

Analysis of heat sources for material joining, Effects of welding parameters on heat distribution, analysis of flow of heat in weld, heat zones in fusion welding. Welding metallurgy and heat treatment of welding.

Unit 2

Modern welding processes like EBW, LBW, Diffusion bonding, Ultrasonic welding, etc, Brazing, soldering, adhesive bonding and solid state bonding. Pulsed current welding processes.

Unit 3

Stresses in welding, weldment design for pressure vessels, heavy structures, offshore structures and submarine pipe lines. Welding of ceramics, plastics, composites. Influence of oxides, slag and fluxes on welding of ceramics, plastics and composites.

Unit 4

Inspection and testing of welds. Inspection codes for weldments.

Failure of welds. Liquid penetrate inspection, magnetic particle inspection, eddy current, ultrasonic x-ray testing and NDT of welds.

Text Books/References:

1. M.M. Schwartz: Metal Joining Manual, McGraw Hill, New York.
2. L. P. Connur: Welding Handbook (Vol. I and II), American Welding Society.
3. P.T. HouldCraft: Welding Process Technology, Cambridge University Press.
4. W. J. Paton. The science and practice of welding, Prentice Hall Inc., New Jersey.
5. R.W. Messler: Principles of welding, John Wiley & Sons, New York.
6. Raymonds Sacks: Welding: principles & practices, Chas A. Bennett Co., Illinois.

ME367(b) (PEC) PLASTICITY AND METAL WORKING

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Explain stress measures and yield criteria.
CO2: Analyse plastic flow through dies and rollsby slip line theory and upper bound analysis in forging, extrusion and drawing operations.
CO3 Design dies for extrusion and drawing.
CO4: Design rolls for rolling of strips and plates.
CO5: Demonstrate knowledge of thickness measurement during rolling.

Unit 1

Principal stresses and principal axes of stress, mean stress and stress deviator.

VonMises yield criteria, Tresca's yield criteria. Comparison of yield criterion. Introduction to slip line theory and upper bound analysis. Forging of discs.

Unit 2

Flow through conical converging dies, upper bound and free body equilibrium approach.

Unit 3

Wire and rod drawing and open die extrusion. Tube sinking. Principles of die design.

Unit 4

Rolling : Theory of Rolling. Determination of rolling loads and torque. Design of rolls and camber. Rolling of strips and plates. Thickness measurement methods.

Text Books/References:

1. A. Ghosh and A. K. Mallik: Manufacturing Science.
2. C. K. Singh and Balbir Singh: A Text Book of Production Engineering.
3. P. C. Sharma: A Text Book of Production Engineering, S. Chand & Co., New Delhi.
4. A. Mendelson: Plasticity.

ME367(c) (PEC) MANUFACTURING AUTOMATION

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:	
CO1:	Summarize different types and degrees of automation in manufacturing.
CO2:	Describe various mechanical, electrical, hydraulic, pneumatic, electronicand hybrid control systems.
CO3	Design a pneumatic and hydraulic automation system.
CO4:	Understand logic control systems using programmable controllers.

Unit 1

Product cycle, manufacturing functions. Types of automation, degree of automation. Technical, economic and human factors in automation. Technologies- Mechanical, electrical, hydraulic, pneumatic, electronic, hybrid systems. Comparative evaluation.

Unit 2

Development of small automation systems using mechanical devices. Basics of pneumatics. Synthesis of circuits. Basics of hydraulics systems, synthesis of hydraulic circuits, elements used for electrical circuits, synthesis, circuit optimisation techniques.

Unit 3

Illustrative examples of the above types of systems as well as hybrid systems used for automation of working cycles of machines, material handling, inspection and assembly systems etc.

Unit 4

Industrial logic control system. Logic diagraming, Programmable controllers, Applications, Designing for automation, Cost-benefit analysis.

Text Books/References:

1. A.N. Gavrilov: Automation and Mechanization of Production Processes in Instrument Industry, Pergamon Press, Oxford.
2. G. Pippengam: Industrial Hydraulics, MGH, New York.
3. F. Kay: Pneumatics for Industry, The Machining Publ. Co., London.
4. Asphal Ray: Robots and Manufacturing Automation,John Wiley, New York.
5. G. Boothroyd and C. Poli: Automatic Assemblt, Marcel Dekkar, New York.

ME367(d) (PEC) RELIABILITY AND MAINTENANCE ENGINEERING

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:	
CO1:	Demonstrate knowledge of statistical fundamentals for reliability analysis.
CO2:	Understand causes of failure and methods of failure analysis.
CO3	Design simulation models for reliability improvement of systems.
CO4:	Describe concepts related to reliability improvement, assessment and testing.
CO5:	Explain various maintenance strategies and associated risks/costs.
CO6:	Explain organisation for maintenance.

Unit 1

Reliability: Meaning, scope and objectives; reliability function and overall reliability; Availability and system effectiveness. Statistical concepts for reliability: Probability distributions and their use – Normal, Log normal, Poisson's, exponential, Weibull, gamma & binomial.

Reliability of Systems: Models of reliability – series, parallel, redundant & Markov model.

Unit 2

Failure: Classification, causes, factors influencing failures; Failure data analysis; Failure analysis for design. General principles of design for reliability.

Risk Assessment: Definition and measurement of risk - risk analysis techniques - risk reduction resources - industrial safety and risk assessment.

Reliability Improvement and Simulation: Design and use of simulation models in reliability; Reliability audits.

Reliability Assessment and Testing: Reliability prediction; Reliability of mechanical and electrical systems. Reliability testing – requirement, methods and standards,

Unit 3

Maintenance: Maintenance information system –objectives and design; implementation; Use of computers in maintenance. Objectives and levels of maintenance

Maintenance practices: Unplanned & planned; Preventive & scheduled; condition based & reliability centered maintenance; Total Productive Maintenance; Maintenance planning and scheduling; Maintainability.

Unit 4

Organisation for Maintenance: Objectives and functions; types of structures; Manpower planning. Materials for maintenance: planning and control.

Economic aspects of Maintenance: Life cycle costing; costs associated with maintenance and optimisation. Safety and Environmental aspects of maintenance.

Text Books/References:

1. R.C. Mishra: Reliability and Maintenance Engineering, New Age International Pub., New Delhi.
2. L.S. Buffa: Modern Production/Operations Management, Wiley Eastern, New Delhi
3. L.S. Shrinath: Mechanical Reliability, Affiliated East-West Press P.Ltd.
4. Modarres: Reliability and Risk analysis, Mara Dekker Inc., 1993.
5. John Davidson: The Reliability of Mechanical system, Institution of Mechanical Engineers, London, 1988.
6. Smith C.O.: Introduction to Reliability in Design, McGraw Hill, London, 1976.

ME367(e) (PEC) PLANT LAYOUT AND MATERIALS HANDLING

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Describe the characteristics of various production systems and plant layouts.
CO2: Explain the contribution of various factors influencing layout.
CO3 Show understanding about steps in systematic layout planning and evaluation of alternatives.
CO4: Demonstrate understanding of challenges in implementation of changes in layout.
CO5: Describe various material handling equipment.

Unit 1

Site Selection: Factors affecting the site selection. Types of plant layout.

Process and Product Type Layout: Types of production activities, job shop, mass production similar products and special product manufacturing.

Unit 2

Factors in Plant Layout: Materials, machinery, man-power, movement, Service building safety, storage and warehouses planning and layout. Process planning, material of building, determination of equipment cost.

Layout Fundamentals: Getting the facts, flow studies. Proximity cross charts, flexibility and layout aids-templates, tapes and production method, evaluation of the layout.

Unit 3

Installing the Layout: Procedure, plant engineering and acceptance

Unit 4

Materials Handling Equipment: Conveyors, cranes, hoists, mobile equipment. Positioning equipment, container and support equipment. Problem of packing. Cost, size considerations.

Text Books/References:

1. G. K. Agarwal: Plant Layout and Material Handling, Jain Brothers, New Delhi.
2. E. S. Buffa: Modern Production Management, Wiley Eastern.
3. Schmid and Puckett: Method Study, Work Measurement, Plant Layout, and Material Handling.
4. S. C. Sharma: Materials Management and Materials Handling, Khanna Publishers, New Delhi.
5. Francis et. al.: Facility Layout and Location: An Analytical Approach, Prentice Hall of India.

FINAL YEAR B.TECH. (Mech. Engg.) – VII Semester

ME471 (PCC) COMPUTER AIDED MANUFACTURING

	L	T	P
Credit	3	0	1
Hours	3	0	2

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Demonstrate knowledge of CAD system components and modelling techniques for computer graphics.
CO2: Demonstrate understanding of numerical control systems and coordinate systems.
CO3 Develop and simulate NC part program for machining of simple parts.
CO4: Understand concepts of cellular manufacturing using Group technology and FMS.
CO5: Explain robot anatomy, components and their classification.
CO6: Explain integration of computer assisted manufacturing with other business functions under CIM.

Unit1

Design process, application of computers for design, benefits of CAD. CAD system components.

Computer graphics: Software configuration of a graphics systems, functions of a graphic package, constructing the geometry, transformations. Wire frame versus solid modeling.

Introduction to numerical control, basic components of NC system, Numerical control, computer numerical control, direct numerical control, Mechanical design of CNC machine tools, MCU configuration.

Unit2

NC coordinate system, Tooling for CNC, Motion control systems, drives, encoders, etc. Point to point straight cut and contouring mode. Adaptive control machining systems.

Part programming: Fundamental punched tape in NC, tape coding and format. Manual part programming using G & M codes for drilling, milling and turning; computer assisted part programming, – APT language Structure, simple exercises.

Unit3

Group technology: Part families, parts classification and coding systems, group technology machine cells, benefits of group technology.

Flexible manufacturing systems: Introduction, components of FMS, application work stations. Computer control and functions - planning, scheduling and control of FMS.

Unit4

Robot technology: Robot physical configurations, basic robot motions, actuators, end effectors and robot sensors, Robot programming, work cell design, control and interlocks

Computer-integrated manufacturing: Types of manufacturing systems, machine tools and related equipment, material handling system, benefit of CIMS.

Practicals:

Use of popular analysis and simulation packages (for example ANSYS, CATIA, etc.) for engineering analysis related to mechanical engineering. Use/Demonstration of CNC programming and simulation software.

The students will be required to undertake a couple of minor projects in analysis and design using computers.

Text Books/References:

1. Steven Harrington: Computer Graphics- A Programming Approach, McGraw Hill.
2. D.F. Rogers and A. Adams: Mathematical Elements for Computer Graphics, McGraw Hill Inc., New York
3. I.D. Faux and M.J. Pratt: Computational Geometry for Design
4. M. P. Groover and E.W. Zimmers: CAD/CAM- Computer Aided Design and Manufacturing, Prentice-Hall of India, New Delhi.
5. Surendra Kumar and A.K. Jha: Technology of Computer Aided Design and Manufacturing CAD/CAM,

Dhanpat Rai & Sons, Delhi.

ME472 (PCC) MECHATRONICS

	L	T	P
Credit	3	0	1
Hours	3	0	2

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Demonstrate knowledge of static & dynamic characteristics of measurement systems and treatment of uncertainties in experimental measurements.
CO2: Describe principle of operation of various transducers & their characteristics, signal conditioning, display systems,standards of measurement and calibration.
CO3 Describe arrangements and computations involved for measurement of displacement, force, torque, pressure, power, flow, temperature and vibration using variety of sensors/transducers.
CO4: Select appropriate sensor/transducer and setup a system for measurement of various quantities occurring in mechanical engineering field.
CO5: Demonstrate knowledge of control systems employed in industry and their stability characteristics.

Unit 1

Measurement: Generalised measurement system, instrument classification, standards of measurement, calibration.

Static and Dynamic Characteristics: Static performance parameters. Impedance loading and matching. Types of errors and uncertainties, propagation of uncertainties, statistical treatment of uncertainties, single sample and multi sample data, goodness of fit, dynamic response. Compensation.

Transducer and Signal Conditioning Elements: Various Primary and secondary transducers. Digital transducers. Introduction to signal conditioning elements.

Terminating Devices: Analog electric meter indicators, electronic counters, digital multimeters, cathode ray oscilloscope, oscillographs, galvanometric type and servo type potentiometric recorders, x-y plotters, single point and multi-point recorders.

Unit 2

Strain and Stress Measurement: Resistance strain gauges, backing materials, bonding materials and methods, gauge factor, gauge configuration, strain gauge bridge circuits, temperature compensation, calibration, semiconductor (piezo-electric) strain gauge. Indicating device. Use of strain gauges on rotating shafts. Strain gauge rosettes.

Force and Torque Measurement: Hydraulic and pneumatic load cells. Strain gauge and piezo-electric based load cells. Separation of force components, calibration. Torque transducers.

Pressure Measurement: Bourdon type gauge, Low and high pressure measurement, Mcleod gauge, thermal conductivity gauge, ionisation gauge, strain gauge, pressure cells. Dynamic pressure measurement. Calibration and testing.

Unit 3

Temperature Measurement: Bimetallic, pressure, metal resistance thermometers. Thermisters, thermo-electric thermometering. Thermocouple, laws of thermocouple, calibration. Error compensation. High speed temperature measurement. Pyrometry, optical pyrometers.

Displacement Measurement: Transducers for displacement measurement, LVDT, resistance strain gauge. Angular velocity measurement, photocell method, Stroboscope.

Vibration Measurement: General theory of seismic instruments. Vibration pick-ups, accelerometers, transducers for vibration pickups and accelerometers, calibration. Frequency measurement, FFT analyser.

Unit 4

Flow Measurement: Positive displacement and obstruction meters, measurement by drag effects. Hot wire and magnetic flow meters. Flow visualisation methods - Schileren technique, pressure probes.

Miscellaneous Measurement: Water level measurement. Acoustic measurement, sound level meter.

Control Systems: Concept of open and closed loop system. Feedback. Servomechanisms and servo-systems. Representation of control systems, block diagrams. Hydraulic, electric, and pneumatic systems. Concept of stability.

Practicals:

Experiment on temperature measurement using thermocouple and calibration, temperature measurement using RTD and thermisters, Water level measurement using capacitive transducer, strain measurement, characteristics of LVDT, vibration measurement, pressure gauge calibration and force measurement.

Text Books/References:

1. B.C. Nakra and K. K. Chaudhry: Instrumentation Measurement and Analysis, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
2. D. S. Kumar: Mechanical Measurements and Control, Metropolitan, New Delhi.
3. Thomas G Beckwith, N. Lewis Buck and Roy D Marangoni: Mechanical Measurements, Narosa Publishing House, New Delhi.
4. K. Ogate: Modern Control Engineering, Prentice Hall of India.

ME473 (PCC) POWER PLANT ENGINEERING

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Understand factors for selection of suitable power plant for given geographical and load conditions.
CO2: Understand the subsystems, components and equipment of conventional power plants.
CO3 Demonstrate knowledge of physical concepts and different types of nuclear power plants.
CO4: Describe the principle of operation, characteristics of unconventional and renewable methods of power generation.
CO5: Perform power plant load and tariff calculations.

Unit 1

Introduction: Introduction to generation of electrical power, sources of energy, comparative merits, principal types of power plants. Review of growth of power and development of different types of power plants in India, future possibilities.

Hydro Electric Power Plants: Site selection, classification, different types of hydro-electric power plants and their field of use. General layout of storage type of plant. Primemovers and selection of turbine.

Unit 2

Steam Power Plants: Selection of site, general layout of plant. Supply, storage and handling of coal. Coal feeding and burning methods, related equipment, pulverised fuel systems and furnaces. Ash handling and dust collectors. Draught systems, condensers, spray ponds and cooling towers, feed water treatment. Steam pipe materials, types of joints and fittings, expansion joints and pipe lagging. Commissioning and testing of power plants.

Diesel Power Plants: Fields of use, components of diesel electric power plant, types of diesel engines used, performance of diesel electric power plant, comparison with steam power plants.

Unit 3

Gas Turbine Power Plants: Components of gas turbine power plant, open cycle and closed cycle plants, choice of working fluid, arrangement of plant components. Combined gas and steam power plant. Comparison with diesel and steam power plants.

Nuclear Power Plants: Elementary concepts of physics of energy generation by nuclear fission. Nuclear reactor types and classification, boiling water reactor, gas cooled reactor, analysis of steam-gas system, organic cooled moderate reactors, liquid metal cooled reactors. Liquid fuel reactors, breeders and fast reactors. Radiation shielding, radio-active waste disposal, safety aspects. Selection of site. Nuclear fuel production and handling.

Unit 4

Unconventional Methods of Power Generation: Introduction to solar energy and its utilisation, solar cells, thermo-electric and thermionic devices, fuel cells, magnetohydrodynamic energy conversion, geothermal, tidal and wind power plants.

Power Plant Economics: Plant costs. Influence of interest rate, depreciation, operating costs on the selection of equipment. Incremental cost. Comparison of operating costs of thermal, hydel and nuclear power plants. Different systems of tariff. Load prediction and curves. Influence of load factor, capacity factor, utilization factor and diversity factor on plant location and selection of unit sizes.

Text Books/References:

1. S. Domkundwar and S. C. Arora, A course in power plant engineering, Dhanpat Rai & Sons, Delhi.
2. P.K. Nag: Power Plant Engineering – Steam & Nuclear, TMH.
3. Skrotzki: Power Station Engineering & Economy, McGraw Hill.

ME474 (PCC) GAS DYNAMICS AND TURBINES

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Apply fundamental relations for analysing compressible flow through converging and converging-diverging ducts.
CO2: Explain the formation of normal shock waves in compressible flow.
CO3 Describe various gas turbine cycles and combustion chambers.
CO4: Describe positive displacement air compressors.
CO5: Analyse centrifugal compressors, axial flow compressors and axial flow gas turbines for computing efficiency and work output.
CO6: Describe jet & rocket propulsion systems.

Unit 1

Elementary Gas Dynamics: Integral equation of conservation of mass, momentum, and energy as applied to control volumes. One dimensional flow equation, sonic velocity, Mach number and waves. Isentropic flow of perfect gas, stagnation properties. Isentropic flow through converging and converging-diverging nozzles, critical pressure, choking, operation under varying pressure ratios. Adiabatic flow with friction in constant area ducts, Fanno relations. Normal shock, formation of shockwaves, governing equations.

Unit 2

Gas Turbine Cycles: Carnot cycle, Joule cycle, Sterling cycle, Brayton cycle, Ericsson cycle, Atkinson cycle. Closed and open cycles. Cycles with regeneration, heat exchanger, intercooling and reheating. Deviation from ideal cycle, cycles with multistage compressions, losses in actual cycles. Various efficiencies, polytropic efficiency and turbine performance.

Combustion Systems: Types of combustion chambers, combustion chamber arrangements. Combustion efficiency. Fuel injection systems.

Unit 3

Positive Displacement Air Compressors: Classification of air compressors. Work done, thermal and volumetric efficiency, effect of clearance in reciprocating air compressors. Multistage reciprocating air compressors, intercooling. Positive displacement rotary compressors, roots blower, Lysholm, screw type and vane type.

Centrifugal Compressors: Euler's equation for rotating machines, general thermodynamic energy analysis. Elementary aerofoil theory. Constructional details, method and theory of operation of centrifugal compressors. Energy transfer, velocity triangles. Slip factor, power input factor, pressure coefficient, efficiency. Sizing of inducer section, prewhirl. Impeller types, effect on performance. Diffuser. Losses in compressors, compressor characteristics. Surging and choking.

Axial Flow Compressors: Description, principle of operation. Efficiencies, workdone and torque calculation, velocity triangles. Degree of reaction. Aerofoil blading, drag and lift coefficients. Performance Characteristics. Centrifugal v/s axial flow compressors.

Unit 4

Axial Flow Gas Turbines: Impulse and reaction turbines, degree of reaction, compounding, reheat factor. Efficiencies, workdone and torque calculation. Velocity triangles.

Jet and Rocket Propulsion: Ram jet, pulse jet, turbo jet and turbo prop engines. Thrust and efficiencies calculation. Thrust augmentation methods. Classification of rockets. Description of liquid and solid propellant rockets.

Text Books/References:

1. P. R. Khajuria and S. P. Dubey: Gas Turbines and Propulsive Systems, Dhanpat Rai & Sons, New Delhi.
2. M. L. Mathur and F. S. Mehta: Thermal Engineering, (Vol. I & II, SI Edition), Jain Brothers, New Delhi.
3. E. Rathakrishnan: Gas Dynamics, PHI.

ELECTIVE-III

ME475(a) (PEC) NON-CONVENTIONAL ENERGY SOURCES

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Summarize effect of conventional energy sources on environment and role of alternative sources in this context.
CO2: Discuss potential of wind energy and various technologies of utilization of wind energy.
CO3 Describe solar radiation/insolation, measuring instruments and transmission properties of materials.
CO4: Discuss various technologies for utilizing solar energy.
CO5: Describe technologies for utilization of geothermal and ocean energy.
CO6: Describe various techniques of using biomass as fuel.

Unit 1

Conventional and Alternative Energy Sources: Effect on environment of fossil, fuels, nuclear energy and hydroelectric power. Alternative energy sources- solar, wind, geothermal, tidal and wave, biomass etc.

Wind Energy: Nature and potential, wind mill types, their merits and demerits, design of wind rotors and control systems. Wind farms.

Unit 2

Solar Energy: The sun and the earth, spectral distribution of extra-terrestrial radiations. Solar constant, depiction of solar radiation in the atmosphere. Solar radiation at the earth surface, sun earth angle, derived solar angles, solar time measurement and estimation of solar radiation. Instruments for measurement, radiation properties of gauge material, transmission of radiation through transparent media.

Collection of Solar Energy: Flat place collection construction, types, working, material selection, design considerations and testing procedure. Focussing collectors types, concentration tracking mechanism. Application of solar energy- Solar water and air heaters, distillation, drying of materials, power generation, cookers, solar refrigeration. Photo voltaic technology.

Unit 3

Geothermal Energy: Geological setting, different geothermal systems, utilisation of geothermal energy, its economical and environmental comparison. Brief description of different utilisation techniques for ocean thermal energy, tidal and wave energy.

Unit 4

Biomass: Nature and potential, different bio conversion techniques, production of bio solid, liquid and gaseous fuels.

Text Books/References:

1. A. N. Mathur and N. S. Rathore: New and Renewable Energy Sources, Bohra Ganesh Publishers, Udaipur.
2. G. D. Rao: Non Conventional Energy Sources, Khanna Publishers, New Delhi.

ME475(b) (PEC) ADVANCED REFRIGERATION

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Describe various practical and advanced refrigeration cycles.
CO2: Evaluate the performance of various refrigerating system using exergy approach.
CO3 Describe methods of chilling, freezing and freeze dehydration.
CO4: Explain microbiology of food and food preservations methods.
CO5: Design energy efficient cold storage systems.

Unit 1

Brayton refrigeration cycle, regenerative Brayton refrigeration. Martionvsky-Dubinsky cycle, vapour compression cycle.

Unit 2

Multistage and cascade, air liquefaction cycles. Exergy approach for energy efficient design of refrigeration systems.

Unit 3

Theories and methods of chilling, freezing and freeze dehydration.

Unit 4

Microbiology of foods. Food preservation methods. Design of cold storage.

Text Books/References:

1. ASHRAE Handbook- Fundamentals.
2. J.L. Threlkeld: Thermal Enviromental Engineering, Prentice Hall Inc.

ME475(c) (PEC) AIR CONDITIONING SYSTEM DESIGN

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Estimate the heating/cooling load for a given application.
CO2: Explain the different air-conditioning systems and equipment employed.
CO3 Design cooling tower, air cleaner and scrubber.
CO4: Understand the various controls and noise reduction methods.
CO5: Demonstrate knowledge of energy efficient air conditioning systems for industrial applications.

Unit 1

Load Estimating: Comfort conditions, weather data, solar heat gain, cooling and heating loads.

Unit 2

Air-conditioning Systems: Central and unitary systems, duct design and fan selection, heating and cooling coil design.

Unit 3

Cooling tower design and selection, air cleaners and scrubbers, hydonic heating and cooling systems, humidification and dehumidification equipment, automatic control, noise reduction. Selection of materials.

Unit 4

Energy conservation and air-conditioning for special applications: Waste heat, recovery, cogeneration of power and refrigeration, industrial air-conditioning, textile processing, clean spaces.

Text Books/References:

1. ASHRAE Handbook- Fundamentals.
2. ASHRAE Handbook: HVAC Systems and Equipment.

ME475(d) (PEC) COMPUTATIONAL METHODS IN THERMAL AND FLUID ENGINEERING

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Explain conservation equation employed in thermal and fluid systems and the lumped parameter approach for their solution.
CO2: Solve non-linear equations.
CO3 Solve system of linear equations using direct and iterative numerical methods.
CO4: Apply linear and nonlinear regression techniques to correlate experimental data

CO5: Understand characterisation of ODEs.
CO6: Solve ODEs using marching and finite difference methods.

Unit 1

Review of conservation equations, lumped parameter approach leading to non-linear equations, numerical solutions of non-linear equation. Concept of round off error, overflow, propagation of error.

Unit 2

Problems leading to system of linear equations. Techniques for solving system of linear equation (direct and iterative). Scaling and nondimensionalisation.

Unit 3

Linear and nonlinear regression techniques to correlate experimental data. Numerical integration, calculation of shape factor.

Unit 4

Thermal and fluid problems leading to ODE. Initial, boundary and eigenvalue problems. Solutions of ODE using marching and finite difference methods. Characterisation of partial differential equation, numerical solutions of elliptic, parabolic and hyperbolic equations encountered in heat transfer and fluid flow.

Text Books/References:

1. T. Cebeci and P. Bradshaw: Physical and Computational Aspects of convective Heat Transfer, Springer-Verlag.
2. T. Cebeci and P. Bradshaw: Momentum Transfer in Boundary Layers, McGraw Hill.
3. S.V. Patanker: Numerical Heat Transfer and Fluid Flow, McGraw Hill.
4. C. Hirsch: Numerical Computation of Internal and External Flows (Vols. 1 & 2), John Wiley & Sons.
5. C.A.J. Fletcher: Computational Techniques for Fluid Dynamics (Vols. 1 & 2), Springer Verlag.

ME475(e) (PEC) THEORY AND DESIGN OF FLUID MACHINERY

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Understand the fundamental equations for rotodynamic fluid machines.
CO2: Analyse performance characteristics of rotodynamic fluid machines using similarity laws.
CO3 Analyse performance characteristics of positive displacement pumps and machines using similarity laws.
CO4: Perform hydraulic design of centrifugal pumps, blowers and hydraulic turbines.

Unit 1

General Classification: Equations of work transfer for rotodynamic type machinery. Operation, performance and similarity laws of rotodynamic type pumps, fan, blower and compressor. Cavitation in pumps.

Unit 2

Hydraulic design of centrifugal type pump and blower.

Unit 3

Positive Displacement type and Jet Pump Type machinery: Impulse type and reaction type hydroturbines; operation, performance, similarity laws, governing, runaway speed.

Unit 4

Hydraulic design of impulse type and radial flow type hydro turbines.

Text Books/References:

1. S. Nagaratnam: Fluid Machines and Systems, Tata McGraw Hill Publishing Co.
2. V.M. Cherkassky: Pumps, Fans, Compressors, MIR Publishers.
3. J. Matley: Fluid Movers: Pumps, Compressors,Fans and Blowers, McGraw Hill Publication.
4. G.I. Krivchenko: Hydraulic Machines: Turbines and Pumps, MIR publishers.

OPEN ELECTIVE COURSES

ME478(a) (OE) ENTREPRENEURSHIP AND INDUSTRIAL MANAGEMENT

	L	T	P
Credit	2	0	1
Hours	2	0	2

Course Outcomes:	Upon completion of this course the students will be familiar with:
CO1:	Selection and development of a small or medium business idea
CO2:	Make and Implement project proposals and reports to hunt for venture capital etc.
CO3	Market competition and innovation in products and processes.
CO4:	Develop managerial skills to achieve goals, & Plan and implement projects applying management techniques.
CO5:	Understand social responsibility as a modern management concept.

UNIT-1

Entrepreneurship: - Definition and Meaning; Characteristics of Entrepreneurship / Traits of an Entrepreneur; Functions of Entrepreneurship - Job Creation, Innovation, Inspiration, Economic Development; Types of Entrepreneurship, Entrepreneurship and Intrapreneurship, Entrepreneurship Strategy

The Business Plan: Creating and Starting the Venture: The Marketing Plan, The Financial Plan, Sources of Capital; Legal Issues for the Entrepreneur: Patents, Trademarks, Copyrights, Trade Secrets, Licensing, Product Safety and Liability, Insurance; Contracts, Advertising, Supply Chain Management, Retail & FDI

Proposals & risks: Project Report Preparation (Feasibility, Cost Estimation, CVP Analysis, Detailed Project Report, Concept of Risk and decision making, Risk Management-SWOT etc

UNIT-2

Entrepreneurship and Innovation: The Innovation Concept, Importance of Innovation for Entrepreneurship, Source of Innovation for Opportunities, The Innovation Process, Product life cycle, new product development process, mortality curve, Creativity and innovation in product modification/ development

Entrepreneurship and Economic Development: Role of Entrepreneurship in Modern Economy, Managers Vs Entrepreneurship**:** Characteristic of Managers, Characteristic of Entrepreneurs, Similarities and differences between Managers and Entrepreneurs

UNIT-3

Industry, Commerce and Business: Types of ownership in the organization- Definition, characteristics, Merits & Demerits; Single ownership, Partnership, Cooperative Organizations, Joint Stock Companies, Government owned, Differences between Management and Administration, Leadership Models.

Industry Size & Current schemes: Micro, Small, Medium- Industry; Registration Process, Current Promotional Schemes for new Enterprise

UNIT-4

Function of Management: Planning- Types of Planning - Strategic Plan, Tactical Plan and Operation Plan; Organizing- Definition and Meaning, Types of Organizing; Staffing- Definition and Meaning, Types of Staffing – Internal & External, The Basic Steps in the Staffing Process; Directing (Leading)- Definition and Meaning; Controlling**-** Definition and Meaning, Relationship between Planning and Controlling.

Social Responsibility: Social Obligation, Social Responsiveness and Social Responsibility, Managerial Ethics

Practicals:
As per the syllabus of theory.

Text Books/References

1. Entrepreneurship Development and Management, A. K. Singh, Jain Book Agency (JBA)

publishes, New Delhi
2. Small Scale Industries and Entrepreneurship, Vasant Desai, Himalaya 2008
3. Industrial Engineering and Management, O.P.Khanna, Dhanpat Rai and Sons, Delhi
4. Industrial Management and Entrepreneurship, V. K. Sharma, Scientific Publishers, New Delhi.
5. Entrepreneurship, Roy Rajeev, Oxford Latest Edition.

ME478(b) (OE) BIO-ENERGY SYSTEMS DESIGN

	L	T	P
Credit	2	0	1
Hours	2	0	2

Course Outcomes:	Upon completion of this course the students will be familiar with:
CO1:	Classifybioenergy fuels and their conversion technologies.
CO2:	Describe the knowledge for operation of biomass gasifier, biomass pyrolysis and biogas plant.
CO3	Design system for biomass gasification, pyrolysis and biogas production.
CO4:	Demonstrateproduction of biodiesel and bioethanol, and their application power generation and transportation.
CO5:	Demonstrate socio-economic aspects and cost-economics analysis of biomass conversion technologies.

Unit – 1

Introduction: Introduction to bio-energy from, classification of biomass as fuel – Agro based, Forest, residue. Bio-energy systems/Conversion devices – Incinerators, gasifiers, digestors.Design objectives for sustainable bio-energy systems.Bio-mass bricketing machine.

Biomass conversion processes, Thermo chemical conversion, Direct combustion, biomass gasification, pyrolysis and liquefaction, biochemical conversion, anaerobic digestion.

Unit – 2

Bio-mass Combustion: Basics of combustion, Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Unit – 3

Bio-mass Gasification: Working principle, Gasifiers – Fixed bed system – Downdraft and updraft gasifiers,Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Bio-mass Pyrolysis: Pyrolysis – types, slow, fast; Manufacture of charcoal: methods -yields and application; Manufacture of pyrolytic oils and gases, yields and applications.

Unit – 4

Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status, Design and constructional features; Biomass resources and their classification for biogas.

Review of mechanical Design: Materials of Construction, corrosion damage, testing and inspection.

System modelling: Basics and its mathematical model, Use of Software in system design. Economicsanalysis of bio-energy systems.

Practicals:

To study gasification process of biomass. To study on bio-syngas compressor. To study performance of SI engine fuelled with bio-syngas. To study thermal application of bio-syngas. To study on condenser of biomass-vapour. To study the design of biomass gasification system.To study on preparation of biodiesel by using Karanja oil. To study performance of compression engine fuelled with biodiesel. To study performance of compression engine fuelled with biodiesel and ethanol dual fuel mode

References:

1. PrabirBasu, Biomass Gasification, Pyrolysis and Torrefaction: Practical Design and Theory, Academic Press, Elsevier, 2018.

2. John Rezaiyan, Nicholas P. Cheremisinoff, Gasification Technologies, Taylor & Francis, 2005.
3. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
4. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
5. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
6. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

ME478(c) (OE) ENERGY CONSERVATION AND MANAGEMENT

	L	T	P
Credit	2	0	1
Hours	2	0	2

Course Outcomes:	Upon completion of this course the students will be familiar with:
CO1:	To understand the basic knowledge ofdifferent terms & principles of energyconservation,audit and management
CO2:	To understand efficient heat utilization, saving andrecovery in different thermal system
CO3	To prepare energy audit report fordifferent energy conservation instances
CO4:	To Evaluate the energy saving &conservation in different mechanical utilities

Unit - 1

Energy Scenario: Commercial and Non-Commercial Energy, Primary Energy Resources, Commercial Energy Production, Final Energy Consumption, Energy Needs of Growing Economy, Long Term Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy and Environment: Air Pollution, Climate Change, Energy Security, Energy Conservation and its Importance, Energy Strategy for the Future, Energy Conservation Act-2001 and its Features.

Unit - 2

Energy Management & Audit: Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments.

Financial Management: Investment-need, Appraisal and criteria, Financial analysis techniques- Simple pay back period, Return on investment, Net present value, Internal rate of return, Cash flows, Risk and sensitivity analysis; Financing options, Energy performance contracts and role of ESCOs.

Unit - 3

Energy Monitoring and Targeting: Defining monitoring & targeting, Elements of monitoring & targeting, Data and information-analysis, Techniques -energy consumption, Production, Cumulative sum of differences (CUSUM).

Global Environmental Concerns: United Nations Framework Convention on Climate Change (UNFCC), Kyoto Protocol, Conference of Parties (COP), Clean Development Mechanism (CDM), Prototype Carbon Fund (PCF), Sustainable Development.

Unit - 4

Energy Efficiency in Thermal Utilities and systems: Boiler efficiency calculation, evaporation ratio and efficiency for coal, oil and gas, Boilers: Types, combustion in boilers, performances evaluation, analysis of losses, Condensate and flash steam recovery system, identifying opportunities for energy savings, Cupola, non-ferrous melting, Induction furnace, performance evaluation of a furnace, hot air generators, Feed water treatment, blow down, energy conservation opportunities, Furnaces: Classification, general fuel economy measures in furnaces, excess air, heat distribution, Soot blowing and soot deposit reduction, reasons for boiler tube failures, start up, shut down and preservation, Steam System: Properties of steam, assessment of steam distribution losses, steam leakages, steam trapping, Steam utilization, Performance assessment more details, installation, Temperature control, draft control, waste heat recovery. Forging furnace heat balance, Thermic fluid heaters, super critical boilers, Thermo-compressor, steam pipe insulation, condensate pumping, steam dryers

Cogeneration: Definition, need, application, advantages, classification, saving potentials. Heat balance, steam turbine efficiency, tri-generation, micro turbine. Heat Exchangers: Types, networking, pinch analysis, multiple effect evaporators, condensers, distillation column, etc. Waste Heat Recovery: Classification, advantages and applications, commercially viable waste heat recovery devices, saving potential. Insulation and Refractories: Insulation-types and application, economic thickness of insulation, heat savings and application criteria, Refractory-types, selection and application of refractories, heat loss. Cold insulation. Heating, ventilation, air conditioning (HVAC) and Refrigeration System: Factors affecting Refrigeration and Air conditioning system performance and savings Opportunities. Vapor absorption refrigeration system: Working principle, types and comparison with vapor compression system and saving potential, heat pumps and their applications, section on ventilation system, ice bank system, and performance assessment of window and split room air conditioners, Star labeled pumps, cold storage refrigeration, and humidification system.

Practicals:

1. A brief study on Energy Scenario and Energy Conservation Act 2001
2. A brief study on financial management in energy sector
3. A brief study on Energy targeting and monitoring
4. A brief study on Energy Management & Audit
5. Energy Performance assessment of boiler
6. Energy Performance assessment of steam system
7. Energy Performance assessment of furnace
8. Energy Performance assessment of insulation and refractories
9. Energy Performance assessment of heat exchangers
10. A brief study on Commercially viable waste heat recovery devices
11. Energy performance assessment of window and split room air conditioners
12. A brief study on Energy and environment

Text Books/References:

1. Energy Conservation Guidebook, Dale R Patrick, Stephen W Fardo, 2nd Edition, CRC Press
2. Handbook of Energy Audits, Albert Thumann, 6th Edition, The Fairmont Press
3. Bureau of Energy Efficiency Reference book: No.1, 2, 3 4
4. Energy Management Handbook, W.C. Turner, John Wiley and Sons, A Wiley Interscience publication
5. Carbon Capture and Sequestration: Integrating Technology, Monitoring, and Regulation dited byE J Wilson and D Gerard, Blackwell Publishing
6. Heating and Cooling of Buildings - Design for Efficiency, J. Krieder and A. Rabl, McGraw Hill Publication, 1994

ME481 (PSI) SEMINAR

	L	T	P
Credit	0	0	3
Hours	0	0	-

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Develop skills for understanding advanced topics by self-study from diverse sources.
CO2: Synthesise and document technical material properly according to a specific style.
CO3 Learn ethical issues in reporting work of others in technical reports.
CO4: Make effective presentations.

The student will be required to take a topic for advanced/in-depth study. He will consult material from diverse sources like books, handbooks, internet, etc.; comprehend the topic and prepare a report. He will also be required to present the report in front of whole class and faculty. A faculty guide shall supervise the work.

ME482 (PSI) PROJECT

	L	T	P
Credit	0	0	15
Hours	0	0	-

Course Outcomes: Upon completion of this course the students will be able to:	
CO1:	Identify and formulate mechanical engineering problems.
CO2:	Demonstrate problem solving skills.
CO3	Demonstrate ability to work in multidisciplinary teams.
CO4:	Apply basic knowledge in mathematics, science and engineering to design a mechanical/thermal system or process.
CO5:	Write a technical report in specified format.
CO6:	Show presentation skills.

The students, working in a group of 3-6 students, will be required to take a project in their final year. The project may include design & development of a product, part, feasibility study or a scientific investigation of a problem. The project work will require the students to apply their knowledge for arriving at a solution. A faculty guide shall supervise the work.

The students shall work for the project in both semesters. However, it will be evaluated and credits counted in the 8th semester only.

Courses for Other Departments

Common Course for II B. Tech. (Mining Engg.) and II B. Tech. (Elect. Engg.)

ME243 (ESC) MECHANICAL ENGINEERING-II

	L	T	P
Credit	2	0	1
Hours	2	0	2

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Demonstrate knowledge of characteristics of power transmission drives with flexible connectors and gears and application forelementary calculations.
CO2: Solve simple balancing problems of rotating and reciprocating masses.
CO3 Describe brakes, dynamometers, bearings, couplings and lubrication methods.
CO4: Explain the sources and types of vibrations encountered in machines.
CO5: Describe the construction and operation of high pressure steam boilers, turbines and condensers.
CO6: Explain various cycles of refrigeration and basic concepts of air-conditioning.
CO7: Demonstrate knowledge of performance characteristics of water turbines and centrifugal pumps required for selection of proper machine.

Unit 1

Transmission of Power: Belts, ropes and chains, length of belts, tension in belts, centrifugal tension and maximum power transmitted by belts. Spur gear nomenclature, involute and cycloidal profiles, helical, bevel and worm gears. Gear trains.

Brakes and Dynamometers: Band brake, block, band and block brake. Single and multiple disc clutches. Transmission and absorption type dynamometers.

Unit 2

Balancing: Balancing of rotating masses in single and multiple planes. Partial primary and secondary balancing of reciprocating masses.

Vibrations: Free, longitudinal, transverse and torsional vibrations, Critical speed.

Bearings and Couplings: Main types of bearings and coupling. Antifriction bearings.

Lubrication: Laws of friction for dry and lubricated surfaces, Methods of lubrication of bearings.

Unit 3

Steam Boilers: High pressure boilers of natural and forced circulation type, La Mont, Benson, Loeffler, Velox Boilers.

Steam Turbines: Expansion of steam through nozzles with and without friction. Throat pressure for maximum discharge. Working of impulse and reaction turbines. Compounding. Velocity diagrams. Governing of turbines. Emergency governing.

Condensers: Types, classification and details. Vacuum efficiency. Cooling towers and spray pounds.

Unit 4

Gas Turbines: Basic principles, simple gas turbine cycle, applications of gas turbines.

Refrigeration and Air Conditioning: Bell-Colleman refrigerator. Vapour compression and absorption refrigerators. Psychrometric Chart. Introduction to comfort air-conditioning.

Water Turbines: Classification and characteristics of various water turbines, governing of turbines. Problem of cavitation. Selection of turbine for hydropower plants.

Centrifugal Pumps: Classification, characteristics of centrifugal pumps. Selection of pumps.

Practicals:

Study of gears, brakes and dynamometers. Study of various types of clutches and antifriction bearings. Study of critical speed of shaft. Study of air compressors. Study of high pressure boilers and condensors. Study of steam and gas turbines. Study and experiments on refrigeration systems. Study of air conditioner.

Text Books/References:

1. M. L. Mathur and F. S. Mehta: Thermal Engineering, (Vol. I & II, SI Edition), Jain Brothers, New Delhi.

2. R. K. Purohit: Thermal Engineering,
3. R. S. Khurmi and J. K. Gupta: Theory of Machines, Eurasia Publishing House (Pvt.) Ltd., New Delhi.
4. P. L. Ballaney: Theory of Machines, Khanna Publishers, Delhi

Courses for B. Tech. (Agricultural Engg.)

ME237 (ESC) HEAT TRANSFER, REFRIGERATION AND AIR CONDITIONING

	L	T	P
Credit	2	0	1
Hours	2	0	2

Course Outcomes: At the end of the course, the student will be able to:

CO1: Apply the principles of conservation of mass, first and second laws of thermodynamics to analyse closed steady state systems and processes involving heat and work interactions.
CO2: Show understanding of concepts of reversibility, entropy and Carnot cycle.
CO3 Demonstrate knowledge of properties of steam and ability to compute them from steam tables and Mollier chart.
CO4: Understand construction and working of steam boilers, steam engines and their specific applications.
CO5: Computer efficiency, power output, etc. of various vapour and gas cycles.
CO6: Demonstrate knowledge about construction and working of IC engines.

Unit I

Introductory concepts, modes of heat transfer, thermal conductivity of different materials, Conduction: General differential equation of conduction. One dimensional steady state conduction through plane & composite walls, tubes and spheres without heat generation, critical thickness of insulation. Convection: free and forced convection. Newton's law of cooling. Dimensional analysis of free and forced convection.

Unit II

Introduction of Radiation, Absorptivity, reflectivity and transmissivity, Black body and monochromatic radiation, Planck's law, Wien's law, Kirchoff's law, grey bodies and emissive power, solid angle, intensity of radiation. Radiation exchange between black surfaces, geometric configuration factor. Heat Exchangers: Types of heat exchangers, fouling factor, log mean temperature difference, heat exchanger effectiveness, NTU method (Only for parallel and counter flow).

Unit III

Second law of thermodynamics applied to refrigeration. Reversed Carnot cycle, coefficient of performance. Unit of refrigeration, vapour compression cycle and components, Compressors, expansion valves, evaporators and condensers Deviation of actual cycle from ideal cycle, Vapour absorption refrigeration system and components, Desirable properties of ideal refrigerant, Classification of refrigerants.

Unit IV

Psychrometry, Thermodynamic properties of moist air, Psychrometric chart and its use, Elementary Psychrometry processes, bypass and sensible heat factor, Air washer, Design of Air Conditioning system, sensible and latent cooling load calculation.

Practicals

1. Measure thermal conductivity of insulating powders.
2. Study temperature distribution along the length of fin in natural convection.
3. Study temperature distribution along the length of fin in forced convection.
4. Experiment on heat transfer in natural convection.
5. Determine emissivity of given surface.
6. Determine rate of heat transfer, LMTD and overall heat transfer coefficient for parallel flow heat exchanger.
7. Determine rate of heat transfer, LMTD and overall heat transfer coefficient for counter flow heat exchanger.
8. Determine COP of vapour compression refrigeration system.
9. Determine COP of heat pump.

10. Study Electrolux refrigerator.
11. Study of domestic refrigerator and
12. Study of one ton ice plant.
13. Study of water cooler.
14. Study of air conditioner.
15. Study of vapour absorption system.

Texts/References

1. D.S. Kumar: Heat and Mass Transfer, SK Kataria & Sons, Delhi.
2. J. P. Holman: Heat Transfer, McGraw Hill.
3. Y. A. Cengel, Heat teransfer, McGraw-Hill
4. F. P. Incropera and D. P. Dewitt: *Fundamentals of Heat and Mass Transfer*, Wiley.
5. S. Domkundwar: A Course in Heat & Mass Transfer, Dhanpat Rai & Sons, Delhi.
6. C. P. Arora: Refrigeration and Air-conditioning, TMH.
7. W. Stoecker: Refrigeration and Air-conditioning, McGraw Hill.
8. J. L. Threlkeld: Thermal Environmental Engineering, Prentice Hall.
9. Khurmi & Gupta: Refrigeration and Air-conditioning, S. Chand Publishing, New Delhi.

ME247 (ESC) AUTO CAD APPLICATIONS

	L	T	P
Credit	0	0	2
Hours	0	0	4

Course Outcomes: At the end of the course, the student will be able to:

CO1: Describe CAD system components.
CO2: Understand and use various drafting and drawing comands.
CO3 Draw 2-D drawings and use 3 D commands.
CO4: Draw production drawings of simple machine components.

Application of computers for design. CAD- Overview of CAD window – Explanation of various options on drawing screen. Study of draw and dimension tool bar. Practice on draw and dimension tool bar. Study of OSNAP, line thickness and format tool bar. Practice on OSNAP, line thickness and format tool bar. Practice on mirror, offset and array commands. Practice on trim, extend, chamfer and fillet commands. Practice on copy, move, scale and rotate commands. Drawing of 2 D- drawing using draw tool bar. Practice on creating boundary, region, hatch and gradient commands. Practice on Editing polyline- PEDIT and Explode commands. Setting of view ports for sketched drawings. Printing of selected view ports in various paper sizes. 2D- drawing of machine parts with all dimensions and allowances. Foot step bearing and knuckle joint. Sectioning of foot step bearing and stuffing box. Drawing of hexagonal, nut and bolt and other machine parts. Practice on 3-D commands- Extrusion and loft. Practice on 3-D commands-on sweep and press pull. Practice on 3-D Commands- revolving and joining. Demonstration on CNC machine and simple problems.

Practicals:

1. Introduction to CAD LAB-1.
2. Line type, Dimensions and Drafting setting.
3. Use of Draw toolbar.
4. Use of Drawing status bar.
5. Use of Modify toolbar.
6. Uses of Geometric constraints and Dimensional constraints.
7. Practice set using- trim, extend, fillet and chamfer commands.
8. Practice set using- Geometric constraints.
9. Practice set using- Dimensional constraints.
10. Practice set using- explode, boundary.
11. Practice set using- copy, mirror, and move commands.
12. Practice set using- polar array and rectangular array.
13. Practice set using- extrusion and loft.
14. Practice set using- revolving and joining.

Text Books/References

1. Steven Harrington: Computer Graphics- A Programming Approach, McGraw Hill.
2. M. P. Groover and E.W. Zimmers: CAD/CAM- Computer Aided Design and Manufacturing, Prentice-Hall of India, New Delhi.
3. Surendra Kumar and A.K. Jha: Technology of Computer Aided Design and Manufacturing CAD/CAM, Dhanpat Rai & Sons

ME248 (PCC) THEORY AND DESIGN OF MACHINES

	L	T	P
Credit	3	0	0
Hours	3	0	0

Course Outcomes: Upon completion of this course the students will be able to:

CO1: Explain the terminology of kinematics and inversions of common mechanisms.
CO2: Describe characteristics of different types of gears and compute velocity ratio of gear trains.
CO3 Perform calculations required for design of belt & chain drives, flywheel and friction drives.
CO4: Describe characteristics of different types of antifriction bearings.
CO5: Demonstrate knowledge of various considerations involved in the design of machines.
CO6: Determine factor of safety and select appropriate material in view of given conditions.
CO7: Design various mechanical components under static loading.

Unit 1

Mechanisms: Elements, links, pairs, kinematic chain, and mechanisms. Classification of pairs and mechanisms. Lower and higher pairs. Four bar chain, slider crank chain and their inversions.
Gear: Types of gears. Law of gearing, Involute and cycloidal profile for gear teeth. Spur gear, nomenclature. Interference and undercutting. Introduction to helical, spiral, bevel and worm gear.
Gear Trains: Simple, compound, reverted, and epicyclic trains. Determining velocity ratio by tabular method.

Unit 2

Power Transmission: Belt drives, types of drives, belt materials. Length of belt, power transmitted, velocity ratio, belt size for flat and V belts. Effect of centrifugal tension, creep and slip on power transmission. Chain drives.
Flywheel: Turning moment diagrams, co-efficient of fluctuation of speed and energy, weight of flywheel, flywheel applications.
Friction: Types of friction, laws of dry friction. Friction of pivots and collars. Single disc, multiple disc, and cone clutches. Rolling friction, antifriction bearings.

Unit 3

Introduction: Meaning of design, Phases of design, design considerations. Common engineering materials and their mechanical properties. Types of loads and stresses, theories of failure, factor of safety, selection of allowable stress. Stress concentration.
Design of joints: Cotter joints, knuckle joint and pinned joints, turnbuckle. Design of threaded fasteners subjected to direct static loads, bolted joints loaded in shear (eccentric loading not included).

Unit 4

Design of shafts, keys and couplings: Design of shafts under torsion and combined bending and torsion. Design of keys. Design of muff or sleeve, and rigid flange couplings. Design of flat belt drives.
Design of brackets, levers.
Design of helical and leaf springs.

Text Books/References:

1. Joseph E. Shigley and John J. Uicker, Jr.: Theory of Machines and Mechanisms (International Edition), McGraw Hill Inc.
2. R. S. Khurmi and J. K. Gupta: Theory of Machines, S. Chand & Co. Ltd., New Delhi.
3. P. L. Ballaney: Theory of Machines, Khanna Publishers, Delhi.
4. Joseph Edward Shigely: Mechanical Engineering Design, McGraw Hill Book Company, Singapore.
5. P.C. Sharma and D.K. Aggarwal: Machine Design, SK Kataria & Sons, Delhi.
6. R. S. Khurmi and J. K. Gupta: A Text Book of Machine Design, S. Chand & Co. Ltd., New Delhi.

ME488 (OE) ENTREPRENEURSHIP AND MANAGEMENT

	L	T	P
Credit	2	0	1
Hours	2	0	2

Course Outcomes:	Upon completion of this course the students will be familiar with:
CO1:	Selection and development of a small or medium business idea
CO2:	Make and Implement project proposals and reports to hunt for venture capital etc.
CO3	Market competition and innovation in products and processes.
CO4:	Develop managerial skills to achieve goals, & Plan and implement projects applying management techniques.
CO5:	Understand social responsibility as a modern management concept.

UNIT-1

Entrepreneurship: - Definition and Meaning; Characteristics of Entrepreneurship / Traits of an Entrepreneur; Functions of Entrepreneurship - Job Creation, Innovation, Inspiration, Economic Development; Types of Entrepreneurship, Entrepreneurship and Intrapreneurship, Entrepreneurship Strategy

The Business Plan: Creating and Starting the Venture: The Marketing Plan, The Financial Plan, Sources of Capital; Legal Issues for the Entrepreneur: Patents, Trademarks, Copyrights, Trade Secrets, Licensing, Product Safety and Liability, Insurance; Contracts, Advertising, Supply Chain Management, Retail & FDI

Proposals & risks: Project Report Preparation (Feasibility, Cost Estimation, CVP Analysis, Detailed Project Report, Concept of Risk and decision making, Risk Management-SWOT etc

UNIT-2

Entrepreneurship and Innovation: The Innovation Concept, Importance of Innovation for Entrepreneurship, Source of Innovation for Opportunities, The Innovation Process, Product life cycle, new product development process, mortality curve, Creativity and innovation in product modification/ development

Entrepreneurship and Economic Development: Role of Entrepreneurship in Modern Economy, Managers Vs Entrepreneurship**:** Characteristic of Managers, Characteristic of Entrepreneurs, Similarities and differences between Managers and Entrepreneurs

UNIT-3

Industry, Commerce and Business: Types of ownership in the organization- Definition, characteristics, Merits & Demerits; Single ownership, Partnership, Cooperative Organizations, Joint Stock Companies, Government owned, Differences between Management and Administration, Leadership Models.

Industry Size & Current schemes: Micro, Small, Medium- Industry; Registration Process, Current Promotional Schemes for new Enterprise

UNIT-4

Function of Management: Planning- Types of Planning - Strategic Plan, Tactical Plan and Operation Plan; Organizing- Definition and Meaning, Types of Organizing; Staffing- Definition and Meaning, Types of Staffing – Internal & External, The Basic Steps in the Staffing Process; Directing (Leading)- Definition and Meaning; Controlling**-** Definition and Meaning, Relationship between Planning and Controlling.

Social Responsibility: Social Obligation, Social Responsiveness and Social Responsibility, Managerial Ethics

Practicals:

As per the syllabus of theory.

Text Books/References

1. Entrepreneurship Development and Management, A. K. Singh, Jain Book Agency (JBA) publishes, New Delhi
2. Small Scale Industries and Entrepreneurship, Vasant Desai, Himalaya 2008
3. Industrial Engineering and Management, O.P.Khanna, Dhanpat Rai and Sons, Delhi
4. Industrial Management and Entrepreneurship, V. K. Sharma, Scientific Publishers, New Delhi.
5. Entrepreneurship, Roy Rajeev, Oxford Latest Edition.